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CONTENTS.

	PAGE
Toothed Whales and their Ancestry. By R. LYDEKKER, B.A.Cantab.	161
Galls and their Occupants—III. By E. A. BUTLER ...	164
The Light-Changes of γ Cygni. By Miss A. M. CLERKE	166
The Great Lunar Crater Copernicus. By A. C. RANYARD	169
Science Notes	172
Letters:—J. R. HOLT; H. ST. A. ALDER; W. T. LYNN; E. F. MACGEORGE: E. W. MAUNDER; A. M. CLERKE ...	173
The Face of the Sky for September. By HERBERT SADLER, F.R.A.S.	178
Chess Column. By C. D. LOCOCK, B.A.Oxon.	179

TOOTHED WHALES AND THEIR ANCESTRY.

By R. LYDEKKER, B.A.Cantab.

WITHIN the entire limits of the great mammalian class, there are, perhaps, no creatures which arouse a larger amount of interest—both among the general public and among naturalists—than those included under the names of whales, dolphins and porpoises, and collectively known as cetaceans. One reason for this universal interest is, doubtless, that among these denizens of the deep are comprised the largest animals, not only of the present day, but likewise, so far as our information allows us to speak, of all epochs. Then, again, the fact that such apparently fish-like creatures are really warm-blooded mammals, suckling their young in the manner distinctive of other members of the class, and being under the necessity of coming to the surface at certain intervals for the purpose of breathing, cannot fail to strike even the most unobservant mind as being something quite beyond the ordinary. Moreover, the momentary glimpses which in general are all we obtain of these animals, and the halo of mystery which still to a great extent enshrouds their mode of life, are likewise important elements in generating the wide-spread interest they arouse. To the zoologist, cetaceans are indeed not only of prime importance as being the sole mammals which have assumed a purely fish-like form, and have become so thoroughly adapted to a completely pelagic life as to be unable to exist on land, but their study gives rise to many problems as to their origin and relationships, and the mode in which they attained their present condition.

As we have already alluded to some of the leading external features of cetaceans in our articles on "Swimming Animals," we need not enter very fully upon these here; merely pointing out that while the general contour of the body is fish-like, the tail-fin, or flukes, differs essentially from that of a fish in being horizontal instead of vertical; while in place of the two sets of paired fins characterizing a fish, a whale has but a single pair of flippers representing the greatly modified fore-limbs of other mammals. The hind limbs have, indeed, been completely lost externally, although more or less imperfect traces of them may still be detected deeply imbedded among the muscles of the body. In the great majority of the group the back is furnished with an upright fin, very similar in appearance to the unpaired back-fin of a fish. Whereas, however, such a dorsal fin is constantly present in fishes, in cetaceans it may be absent or present in different species of the same genus; while if we were to cut through such a fin we should find a total absence of the slender spine-like bones characterizing those appendages in a fish; a similar condition also obtaining in the flukes. In marked contrast to the scaly armour of the majority of modern fishes, the skin of a cetacean is for the most part completely naked; although the frequent presence, in the young state at least, of a few scattered bristles in the region of the mouth is of itself sufficient to indicate the derivation of these strangely modified creatures from more ordinary mammals. As regards their coloration, we may again, however, note a similarity to most pelagic fishes, in that while the upper parts are generally dark, the lower surface of the body is of a light hue; this arrangement being, of course, designed to render all these animals as inconspicuous as possible when viewed in the water either from above or from below. Although the flippers show no external indications of digits, and are unprovided with nails, yet their internal skeleton comprises the same elements as occur in the limbs of any ordinary mammal, and is thus quite different from that of a fish. This structural similarity is, however, to a certain degree obscured by the alteration in the form of the bones, and also by the circumstance that the number of joints in the skeleton of the individual digits is increased beyond the normal. As external ears would be mere useless incumbrances, these appendages are absent; while the aperture of the ear itself is reduced to an extremely minute size. To prevent the ingress of water during the periods of submergence, the apertures of the nostrils, which may be either double or single, can be completely closed

FIG. 1.—The Bridled Dolphin. (From True, *Bull. U. S. Nat. Museum.*)

at will, and are only opened at such times as the creatures come to the surface to breathe, when a column of water is generally thrown up by the rush of expired air let loose shortly before the head reaches the surface. In all their internal structures, as well as in the mode of production and nourishing of their young, cetaceans conform strictly to the ordinary mammalian type; and we accordingly see that their assumption of a fish-like form is, with the exception of the loss of the hind limbs and the modification of the front pair into flippers, mainly superficial. In departing from the fish-type in having the expansion of the tail-fin horizontal instead of vertical, the necessity of having an organ capable of bringing them rapidly to the surface has been the inducing cause; while in order to prevent their blood from being reduced below the proper temperature by the chill of the surrounding water, the whole body is invested with a thick layer of oily fat, commonly known as the blubber, beneath the skin.

As we have had occasion to mention incidentally in previous articles, existing cetaceans are divisible into two great groups, distinguished as the whalebone whales and the toothed whales; the latter group including sperm-whales, together with the grampuses, porpoises, and dolphins. The most obvious distinction between these two groups, as the terms applied to them indicate, relates to the presence or absence in the adult condition of true teeth.

FIG. 2.—The last six upper teeth of the Killer Whale. (After Sir W. H. Flower.)

Confining our attention in the present article to the toothed cetaceans, of which the dolphins and their allies are the best specialized representatives, we find that the two jaws may be in some cases provided with a full series of teeth, while in other forms the number of teeth may be reduced to a single pair, or even, as in the male narwhal, to a solitary tusk. Whether, however, the teeth be many or few (and in the female narwhal there are none of any functional importance), the structure known as whalebone is never developed in the mouth; while all the members of the group are further distinguished from the whalebone whales by the circumstance that the nostrils invariably open by a single external aperture, which is very frequently in the form of a transverse crescentic slit, closed by an overhanging valve. In the latter respect these cetaceans are more specialized than are the whalebone whales; and as the presence of teeth in the former indicates that they could not have been derived from the latter, it is evident that the two groups are of extreme antiquity, and have undergone a parallel development. Till recently, it has indeed been considered that they were divergent branches from some common ancestral type; but, as mentioned in our article on "Parallelism in Development," it has been lately suggested that each may have had a totally distinct origin, although the evidence in favour of such a view is, at present at least, far from conclusive.

In the structure of their teeth, the modern-toothed whales differ very widely from the generality of mammals. In the first place, their teeth are always of the simple structure shown in Fig. 2, having conical or compressed crowns, and undivided roots; while, secondly, there is only one single series developed, the replacement of the anterior ones characterizing the majority of mammals being wanting. From this simple structure of their teeth it has been argued that these cetaceans are among the most primitive of all mammals; but, altogether apart from the conclusive evidence that all whales (as proved by their breathing air) are derived from land mammals, it has recently been shown by the researches of Dr. Kükenthal, of Jena, that this view is quite untenable. By examining embryos of young cetaceans of this group, that observer has demonstrated that there actually are rudiments of a second series of teeth, which, although never coming to maturity, serve to show that there were once two complete sets, and that the permanent teeth correspond, in part at least, to the milk-teeth of other mammals; thus indicating that the present state of the cetacean dentition is a degraded one. Hitherto it has not, indeed, been shown by embryology that the teeth of this group were originally of a complex type (although in the case of the whalebone whales this has been demonstrated), but, fortunately, here palæontology comes to our aid. Thus in the middle of the tertiary period there occur remains of what may be termed shark-toothed dolphins (squalodonts), in which the permanent teeth are differentiated into distinct series, corresponding to the incisors, canines, pre-molars, and molars of other mammals; while, for all we know to the contrary, there may also have been a regular replacement of the more anteriorly placed teeth. In these shark-toothed dolphins the molar teeth, instead of being of the simple structure of those represented in our illustration, were severally implanted in the jaws by two perfectly distinct roots; while their large, laterally compressed, and somewhat fan-shaped crowns were furnished with a number of cusps on their hinder cutting-edges. Indeed, these teeth much resemble the pre-molar tooth of a dog or the molars of a seal; and they obviously serve to indicate a transition from the modern toothed cetaceans towards ordinary mammals. This, however, is by no means all, since in a still earlier portion of the same division of the tertiary there occur other cetacean-like animals known as zeuglodonts, which have still more complicated teeth, and otherwise depart further from the modern cetacean type—so much so, indeed, that they have been regarded by some writers as more nearly allied to the seals. In our opinion they are, however, undoubtedly primitive cetaceans, and thus serve, not only to connect the present group with other mammals, but also, in conjunction with the shark-toothed dolphins, to show that the simple teeth of the former are clearly produced by degeneration from a complex type. As regards the particular group of land mammals from which whales were derived, we have stated in the article on "Swimming Animals" that it has been thought that their nearest allies are with the ancestors of the pig-like hoofed mammals. This, indeed, is the view of Sir W. H. Flower; but we confess that from the nature of the teeth of the two extinct groups above mentioned, coupled with certain resemblances of the skeleton of the zeuglodonts to those of the seals, we are rather more inclined to look among flesh-eating land mammals for the lost ancestors. Still, however, it must be remembered that in the early eocene period, which is probably the very latest epoch at which cetaceans could have originated, the distinction between carnivorous and hoofed mammals was but imperfect, so that, after all, the ancestral cetacean stock may well have been of an extremely generalized type. At present, however, we are almost completely in the dark in all that concerns this interesting subject.

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By far the largest of all the toothed whales is the gigantic sperm-whale, the typical representative of a family characterized by the absence of teeth in the upper jaw of the adult, while those of the lower jaw are very variable both as regards form and number. In the sperm-whale, of which the male attains a length of between fifty and sixty feet, the lower teeth vary in number from fifty to sixty on each side, and are characterized by their large size and pointed crowns, upon which there is not a trace of enamel. Another characteristic feature of this animal is the enormous size of the head, which terminates in an abruptly truncated muzzle of great depth, and in a cavity of which is contained a peculiar oily substance, yielding when refined the well-known spermaceti. An even more valuable product of this animal is ambergris, which, while accumulated as a concretion in the intestine, is generally found floating on the surface of the sea; in appearance it is an amber-coloured substance, containing a number of the horny beaks of the squids on which the sperm-whale subsists.

FIG. 3.—The Indian Porpoise. (From True, *Bull. U.S. Nat. Museum.*)

Omitting mention of the lesser sperm-whale—the only other member of the first division of the family—we pass on to mention the bottle-nosed and beaked whales, characterized by having all the lower teeth, with the exception of a single pair, rudimentary, and concealed in the gum. In the bottle-noses—so named from the extreme convexity of the crown of the head of the adult males, which rises suddenly above the short beak—there is but a single pair of teeth, situated in the front of the lower jaw, and even these are invisible during life. These whales, of which there is but a single well-defined species (*Hyperoödon rostratus*), although not exceeding some thirty feet in length, are valuable on account of their oil, as well as from yielding spermaceti from their skulls. In contradistinction to the sperm-whale, they carry, in common with the beaked whales, a large dorsal fin. In the beaked whales, of which there are three existing genera, the skull is produced into a long beak, of which the upper half is formed by a solid bone of ivory-like density; while in the lower jaw there are either one or two pairs of teeth, which, although variable in position, are generally of large size. It is one of these whales (*Mesoplodon layardi*) which is alluded to in the article on "Tusks and their Uses," as being provided with teeth of such a size as to actually impede the free opening of the mouth. From their general avoidance of the neighbourhood of coasts, and their apparently somewhat solitary habits, extremely little is known of the life-history of the beaked whales, of which the skeletons are but poorly represented in our museums. At the present day very rarely seen in the English seas, during the pliocene period these whales must have been extremely numerous in the North Sea, since their fossilized beaks are amongst the most common vertebrate fossils obtained from the crags of Suffolk and Essex. The same deposits, together with others of corresponding age on the Belgian coasts, have also yielded teeth of a number of extinct whales, more or less closely allied to the sperm-whale, thus indicating that the latter is the last survivor of a once numerous group. The teeth of many of these fossil sperm-whales differed, however, from those of their living cousins in having their crown capped with enamel.

In the general presence of numerous teeth in both the upper and the lower jaws, the dolphins and their allies the porpoises, killers, and white-whale differ from all the above-mentioned forms, and thus constitute a second family—the *Delphinidæ*. The group is a numerous one, which is split up into a number of genera, some of which are by no means easy to distinguish. They may, however, be roughly ranged under two main divisions, in one of which the muzzle is short and rounded, as in the porpoises and black-fish, while in the other, as represented by the dolphins (Fig. 1), it is produced into a longer or shorter beak, of which the base is marked off from the main portion of the head by a distinct re-entering angle. The most aberrant member of the first group is the spotted Arctic narwhal, of which a brief notice, accompanied by a figure, was given in the article on "Tusks." Allied to the narwhal is the beautiful white-whale (*Beluga*), which is likewise a northern species, distinguished by its glistening white skin, the absence of any tusk, and the presence of numerous well-developed teeth in the fore part of the jaws; neither of these species having a back-fin.

Although the name "porpoise" is applied indiscriminately to several members of the family, it should properly be restricted to a few comparatively small-sized species characterized by the presence of some twenty-five small and flattened teeth with spade-shaped crowns on either side of each jaw. Porpoises are among the most common and familiar of all cetaceans, their rolling gambols being well known to all who have made a voyage; but whereas the common porpoise has a distinct back-fin, in the species represented in our illustration that appendage is lacking. Less familiar, on the other hand, are the much larger and handsomely coloured killers, or grampuses (*Orca*), differing by the great size of their teeth (Fig. 2), which are usually twelve in number on each side, and the great development of the back-fin. Attaining a length of about twenty-five feet, the killer derives its title from its rapacious habits; a single specimen having been known to swallow several whole seals in succession, while not unfrequently several individuals have been known to combine their forces to attack and kill the larger members of the order. Killers may always be easily recognized while swimming near the surface by the great height of their nearly vertical back-fins. Allied cetaceans with smaller teeth (*Orcella*) frequent the Bay of Bengal and ascend some distance up the Irrawadi. Another well-marked type is the black-fish, characterized by its remarkably short and rounded head, the uniformly black hue of the skin, and by the eight or twelve small and conical teeth being confined to the front portion of the jaws.

FIG. 4.—The Pacific Black-Fish. (From True, *Bull. U. S. Nat. Mus.*)

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There are other less well-known representatives of this group which we have not space to notice; and we accordingly pass on to say a few words about dolphins—a term which should be restricted to those forms having a distinctly marked beak. Since, however, sailors will persist in speaking of dolphins indifferently, either as bottle-noses or porpoises, the inexperienced landsman must accordingly be on his guard not to confound them when thus spoken of either with the bottle-nosed whales or the true porpoises. Dolphins, which are divided into numerous genera, according to the number of their teeth, the length of the beak, and other characters, are all comparatively small species, seldom exceeding some ten feet in length; and while the great majority are marine, a few ascend some of the larger tropical rivers, such as the Amazon. Fish of various kinds constitute their usual prey; but one peculiar species recently described from the Cameroons district is believed to subsist on sea-weed. Of the better-known types, the common dolphin represents the genus *Delphinus*, the bottle-nosed dolphins constitute a distinct genus (*Tursiops*), while the long-beaked dolphins are separated as *Steno*.

To the foregoing group of beaked dolphins the ordinary observer would, doubtless, be disposed to refer three peculiar species severally restricted to the larger rivers of India, the Amazon, and the mouth of the La Plata river, but as these differ more or less markedly from other dolphins in certain structural features they are referred to a distinct family. Moreover, since these peculiarities approximate to a more generalized type, while their fresh-water habits and scattered distribution indicate extreme antiquity, it is not improbable that these three dolphins are the most primitive of all existing cetaceans. At present we have, indeed, no evidence of fossil forms allied to the susu or Gangetic dolphin (*Platanista*); but in the older tertiary deposits, both of the United States and Europe, there occur the remains of dolphins evidently nearly allied to the two existing South American species (*Inia* and *Stenodelphis*), and thus clearly proving the antiquity of those types. It is almost superfluous to add that it is most probable that the ancestors of the cetaceans which first took to an aquatic life were inhabitants of fresh-water, and it is therefore only what we should expect that the most primitive of the existing representatives of the order were likewise of fluviatile habits.

GALLS AND THEIR OCCUPANTS.—III.

By E. A. BUTLER.

(*Continued from page* 146.)

LEAVING now the oak tree, which we have found so rich in the products of gall insects, and looking about in other directions, we find very few galls formed by the true gall-flies (*Cynipidæ*) that are sufficiently common and conspicuous to have obtained popular names, and only one or two need be referred to. Everyone is, of course, familiar with the bright crimson or greenish-red mossy balls which often appear on the wild rose bushes, and which, formerly known as "briar-balls," and still dear to the heart of childhood under the name of "robin's pincushions," form one of the prettiest ornaments of English hedgerows. These, too, are galls originated by a *Cynipid*, a gall-fly which, though itself of no great beauty, yet owns as its home the most elegant of these fairy-like structures. In this instance, the swollen mass of tissue forming the gall proper is completely concealed by a quantity of moss-like filaments (Fig. 7) like those that envelope the buds of moss roses; these filaments run out from the entire surface of the gall. Each "pincushion" contains a family of the gall-fly (*Rhodites rosæ*), and if they are picked when fully ripe, there is no difficulty in rearing the little red-bodied fly from them. The gall insects, however, are subject to the attacks of a pretty *ichneumon* fly, which is also red-bodied, and hence one must not too readily conclude that any transparent winged creatures that issue from the mossy ball are its legitimate inhabitants. But if attention be paid to the number and arrangement of the nervures of the wings, and to the shape of the body, as described in a former paper, there will be no difficulty in determining whether it is the *Rhodites* or its parasite that is escaping from the gall.

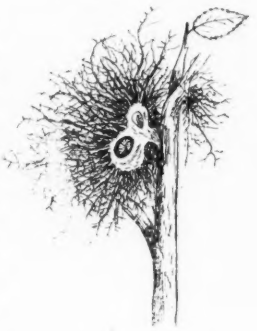


FIG. 7.—Section of Bedeguar of Rose, showing two cells, one containing larva of Gall-fly.

This gall is also known by the name "bedeguar," though that name belonged in the first instance to another object and was incorrectly applied to this. The word is an Arabic one, and originally signified the thorny white flower of a kind of thistle. But, apparently in consequence of a misunderstanding as to its etymology, it was thought to mean some growth connected with a rose tree, and hence was applied to the gall in question. Under the name bedeguar, therefore, the gall was sold in the shop of the apothecary as a drug, and was considered a specific against various serious ailments, being for this purpose ground up and administered as a powder. Its medicinal use is of long standing, and Pliny recommended that it should be mixed with honey and wood-ashes before being taken.

In this rose gall there is not such a disparity in the numbers of the sexes as is found in the various galls of the oak. So far from there being always a preponderance of the female element, the case is sometimes reversed—*e.g.*, from three galls of bedeguar, Schlechtendal once bred thirty-two males and only two females; but the experience of collectors is not uniform in this matter, and Mr. Cameron records a proportion strikingly the reverse—viz., one male to one hundred females. But though males are known and are sometimes numerous, still the insect follows the usual law of the group, and parthenogenesis is not infrequent.

On the under surface of the leaves of wild roses may frequently be seen beautifully coloured, berry-shaped galls, which, save for their opacity, forcibly recall the currant galls of the oak. Some are quite spherical, others consist of globes with three or four long and sharp spikes projecting from them, and remind one of the spiked balls carried at the end of the warlike clubs and maces of olden times. All these galls belong to the same genus as the bedeguar, but each contains only a solitary fly. If cut open, they will be found to be very thin-walled and to have, therefore, a large central cavity (Fig. 8, A); at least this is their condition if they are free from parasites, and the gall-fly is allowed to develop naturally.

A B

FIG. 8.—Sections of Gall of *Rhodites eglanteriæ*. A, normal; B, when containing inquilines. (After Fitch.)

But their internal structure becomes altogether altered if parasitic gall-flies—"inquilines," as we have already called them—take up their abode within. The galls then become many chambered, a number of cavities for the parasites surrounding the cell of the true owner (Fig. 8, B).

But it is time to pass on to another group of gall-makers. The insects called saw-flies, like the gall-flies, also belong to the order Hymenoptera, and like them too, they are vegetable feeders. As a rule they live exposed, and their larvæ differ greatly from the footless grubs of the *Cynipidæ*, and closely resemble those of moths; but the rule of external feeding is not without exceptions, and a few species are to be sought for inside their food-plant, and then comes the possibility of gall-growth. The eggs of saw-flies are generally laid in small slits cut into various parts of plants by means of the pair of "saws" with which the female is provided at the extremity of the abdomen, and usually this incision has very little effect upon the plant attacked. But in some cases an irritation is set up which results in the formation of a gall just as with the true gall-flies; the egg, therefore, becomes enclosed in a vegetable excrescence, and the species is rendered gall-inhabiting. This habit is practised principally by certain species of the large genus *Nematus*, to which belongs the well-known pest that so often strips gooseberry and currant bushes of their leaves. This garden plague, however, is not a gall-producer, but, as everyone knows, feeds on the leaves without any shelter, while clinging to their edges.

The gall-forming section of this genus contains insects which are largely addicted to willow trees, and one of the commonest saw-flies we possess in this country is a minute one called *Nematus gallicola*, which makes oval swellings on the leaves of various kinds of willows (Fig. 9). Everyone must have noticed these reddish swellings on the long, narrow leaves, bulging out on both sides of the leaf, and attaining a length of from a quarter to half an inch, with a breadth of about half as much, seeming as though a fiery blister had been raised by some caustic process. Sometimes several are to be seen on the same leaf, and Mr. P. Cameron, the historian of British saw-flies, records having found a leaf which was disfigured by no less than thirteen specimens. This is an exceptionally large number, for there are generally not more than two or three, and very frequently only one. As half the gall is above and half below the leaf, it is not easy to see its real shape without cutting away the leaf from around it, and then it is found to possess something of the form of a bean.

FIG. 9.—Gall of Saw-fly on willow leaf.

These saw-fly galls differ in a good many ways from those of the gall-flies proper. In the first place, the egg, though it grows like that of the *Cynipidæ*, is not hatched till the gall is fully formed, and therefore the young caterpillar, from the moment that it begins its life, finds itself surrounded by a compact mass of vegetable substance, not more succulent than the rest of the leaf, which has been built up for its special use, and is a store large enough to last its lifetime. It can afford, therefore, to take its time about its development, and consequently feeds up in a leisurely way, not any more rapidly than its companions that adopt the open air life. The cynipid, on the other hand, hatches early, while the gall is still growing, and hurries to get through its larval life while the gall remains very succulent, lest the hardening and drying process should set in before it has obtained all the nutriment it requires. The saw-fly grub, again, eats the greater part or the whole of the contents of the gall, often leaving it ultimately a mere empty bladder of skin; the cynipid, on the other hand, uses only the central portion, making a cavity just large enough to contain itself, while the rest forms a more or less hard wall around it. The saw-fly grub in course of time nibbles a hole through its gall at one end, which it makes use of for sanitary purposes, while the gall-fly proper remains hermetically sealed up throughout its larval life. Finally, the saw-fly grub often leaves its gall when fully grown, or even before that time, and forms its cocoon elsewhere, very frequently in the earth, or on the bark of the tree; the cynipid much more frequently becomes a chrysalis inside the gall, and does not gain the outer air till it has reached its final condition.

The creature that makes these blistery swellings on the willow leaves can be very easily distinguished from a true gall-fly. It has a squarish head, and a more or less cylindrical body attached to the thorax by the whole of its base, and the four wings carry an elaborate network of nervures arranged after a special and rather intricate pattern. By noting these points there can be no difficulty in distinguishing a saw-fly. They are heavy-bodied, sluggish creatures, and most of them are much larger than the gall-flies proper, though, of course, those that inhabit galls are among the smallest of the group. The grubs, too, are very easily distinguished from those of the *Cynipidæ*. Inside the above-mentioned gall there would be found a small white caterpillar with a black head, which would be at once recognized as a different sort of being from what would be found inside an oak-apple or a marble gall. Saw-fly galls are not always soft and fleshy, nor are they always found on leaves. One species makes hard woody galls on the twigs of a certain kind of willow, and sometimes does much damage by dwarfing the twigs and ultimately destroying the trees. Some saw-flies do not go quite so far as to make an actual gall—*i.e.*, a complete enclosure—but merely distort the leaves by turning down and blistering their edges.

For our next group of gall-producers we must go to a different order—the Diptera or two-winged flies. In this order we find more than one group responsible for the disfigurement (or otherwise) of vegetation by abnormal growths, and we shall select for our illustrations two groups of very opposite character. The first of these are called "gall-midges" or "gall-gnats," and constitute the family *Cecidomyidæ*. They are very minute flies like gnats, thin-bodied and long-legged, the very personifications of delicacy and fragility. Though so insignificant in size, they are often pretty little things, red, yellow, or black, but their beauties need the help of the microscope before they can be fully brought out. The galls they make are often conspicuous and elegant productions, and are much better known than the insects that make them. The other family is the *Trypetidæ*, a stout-bodied, short-legged group, more like house-flies in shape. They are prettily coloured, and their wings are marked most distinctly with strongly-coloured bands, a species of adornment which makes them some of the most striking of all dipterous insects. Their galls, which are often formed in the ovaries of plants, are inconspicuous or even quite concealed from view, and even if visible are merely unsightly swellings, so that in this case the flies are more likely to be noticed than their galls.

The larvæ of the gall gnats are generally yellowish or orange footless maggots, of course of very small size. One of the easiest ways to find specimens to illustrate the group is to look out for a hawthorn hedge and to note those twigs that have a sort of tuft of leaves at the tip, twisted, crumpled, and crowded together. On opening

XUM

out the crumpled leaves, a number of little orange maggots may be found, which are the larvæ of one of our commonest gall-gnats. Here the gall consists of little more than a tuft of distorted leaves, but this must not be taken as a universal type; there is every variety of form as well as position, and the plants attacked are as varied as the galls. Thus we have swellings on the midribs of ash leaves and the stalks of aspen leaves; warts, pads, and other deformities on the margins of willow leaves; tufts and rosettes of leaves on willow and yew, and on the pretty little blue speedwell and yellow St. John's wort; bud-like bodies on broom and furze; distorted flowers on cabbage and other cressworts and on the yarrows; blisters on bedstraw, water-cress and box; woody swellings on willow twigs and bramble stems; spongy galls on barberry; woolly galls on weasel-snout; hairy galls on nettles; horns on beech leaves and cylindrical tubes on ground ivy, together with many others too numerous to mention.

As in other cases, so also with the gall-gnats, the most remarkable facts concerning them are connected with their reproduction. We have already seen that amongst the true gall-flies parthenogenesis is an extremely common phenomenon, so that the continuance of the race is doubly secured—first, by the fact that the plant responds to the touch of the insect, as if it had been that of a fairy's wand, and forthwith there upsprings with mushroom-like rapidity a structure combining board and lodging; and secondly, by the fact that there is no need to wait for the meeting of a suitable pair of individuals before fertile eggs can be produced, but that the female, often the only representative of the species present, can proceed at once to lay the foundation of the next generation. And with the gall-making saw-flies the same is true. Mr. Cameron says that he has often bred the fly of the willow-gall above described, but has never met with a male. Mr. F. Smith, however, was more fortunate; but still in his case there was only a single male to several hundreds of females. But when we come to the gall-gnats we find examples of a still more remarkable method of ensuring the perpetuation and multiplication of the race. The reproductive power is carried two stages back in the history of the insect, and we find not merely the perfect insect, but even the *larvæ* gifted with the power of producing young, for which reason the process is called "pædogenesis." Fig. 10 shows the larva

FIG. 10.—Larva of *Cecidomyid* containing five young larvæ. (After Pagenstecher.) Much magnified.

of a cecidomyid which contains within itself five other larvæ. These are produced where they are seen, and they subsist upon the tissues of the parent larva, ultimately absorbing all the contents of the skin, within which they lie free. Rupturing the skin, they escape and proceed with their development. Sometimes several generations of larvæ are produced in this way before we revert again to the full-grown flies. Of course this process involves the destruction of the parent larva, which has no more chance of completing its own development than if it had harboured a set of ichneumon maggots. But notwithstanding this, there is a net gain in the number of individuals ultimately existing, so that the species is in the long run benefited, though by the sacrifice of some of its members.

Our last instance of dipterous galls is from the brilliant and banded-winged *Trypetidæ*. The best known of this group is, no doubt, the common thistle gall. The stems of one of our commonest thistles (*Cnicus arvensis*) are often seen to be swollen near their tips into a large, green, oval, wen-like body. This is the gall of the very handsome dark-bodied fly whose wing is shown in Fig. 11. Its name is *Urophora cardui*. The gall is sometimes partly concealed by the leaves of the thistle, the growth of which it does not interfere with. On cutting open the gall we find a solid mass of tissue, in which are excavated a number of pear-shaped chambers, each containing a single white maggot. There may be as many as eight of these cells in a single gall, or there may be no more than one; usually, however, there are several. The fly is very common, and is pretty sure to be found in plenty wherever the thistle grows. Another species belonging to the same genus attacks the flower-heads of the common "knapweed" or "hard-head," an extremely abundant weed with thistle-shaped but not prickly flowers. In this case, however, the gall is invisible till the flower-head is pulled to pieces, as it occupies the position of the ovaries of the florets, and is therefore concealed by the scaly cup, or involucre, which surrounds them. But though invisible they can be felt from the outside. If the dead flower-head be squeezed between finger and thumb, it will yield to the pressure and more or less flatten out when no gall is present; but when the gall is there, it will be felt as a hard lump which will prevent collapse.

FIG. 11. — Wing of *Urophora cardui*, Gall-making fly of thistle. Magnified seven diameters.

(*To be continued.*)

THE LIGHT-CHANGES OF Y CYGNI.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

ACQUAINTANCE has so far been made with nine variable stars of the Algol type. They are essentially characterized by normal stedfastness of light, interrupted at intervals of a few days or hours by brief phases of darkening. These sudden dips to a lower magnitude represent stellar eclipses; for the certainty on the point, attained spectroscopically in the case of Algol, may safely be extended to its sister stars. They are all, then, very rapid binaries, the orbits of which lie edgewise towards the earth. Plainly, however, this latter condition is extrinsic to the systems themselves; our position with regard to them determines its realization. If it remained unfulfilled, the loss, so to speak, would be ours. The mutual relationships of the stars would be just the same; only we should remain ignorant of them unless the spectroscope came to our assistance. This it could only do if the combined brightness of the revolving bodies sufficed to bring them well within range of our present instruments, and if, in addition, a large proportion of their orbital velocities were directed, at quadratures, in the line of sight.

Two such spectroscopic binaries are particularly well known, and each exemplifies a variety of the class. Thus, Spica (α Virginis) is composed of a brilliant sun, and a relatively obscure, though powerfully attractive body; β Aurigæ of two nearly equal suns. We should accordingly expect to find the same varieties represented among eclipsing binaries. And the companion of Algol seems, in fact, to be completely dark; for if it gave any sensible light, a minor obscuration should be recorded without fail just half-way from each principal eclipse to the next.

That extraordinary star, S Antliæ, on the other hand, is certainly made up, like β Aurigæ, of twin suns, for it undergoes, once in seven hours and three-quarters, phases lasting five hours; and since an eclipse longer than half the time of revolution is a patent absurdity, there can be no hesitation in admitting (with Mr. Backhouse) that the stars occult each other twice while they traverse their orbits once. Nor is any systematic difference perceptible between successive phases. The effect is the same whether number one occults number two, or number two occults number one. The connected stars are hence probably alike in size and brilliancy, although their eclipses can only be partial, the loss of light being less than one-half.

There is another Algol star, however, in which the loss of light is exactly one-half. This in itself suggests alternating occultations by two equal stars, revolving in *twice* the period of variability. The presumption has been accurately verified.

Y Cygni was detected as an Algol variable by Dr. S. C. Chandler on December 9th, 1886. Its phases, carrying it from 7·1 to 7·9 magnitude and back once in about thirty-six hours, had a duration assigned to them of eight hours, equally divided between decline and recovery. But their recurrences were soon found to be subject to enormous irregularities. Towards the middle of 1888 they were no less than seven hours behind their calculated times, which soon after began to be largely anticipated. Never before had perturbations on such a scale been betrayed by the light-changes of an eclipsing binary; still, Dr. Chandler thought that, like those of Algol, they might prove to be dependent upon the varying length of the journeys of light in travelling hither from different parts of a large orbit described by Y Cygni round an unseen primary. The possibly undulating line of its proper motion might even, it was hoped, serve to make these hypothetical revolutions directly measurable.

The problem has, however, received a different solution. M. Dunér,* director of the Upsala observatory, took the star in hand in April, 1891, and observed its minima steadily until April, 1892. But when he came to discuss the results, and compare them with those obtained elsewhere in Europe and America, he was at once struck with a persistent discrepancy between the odd and even sets of minima. The first, third, fifth, seventh, and so on, from a given epoch, obeyed a law quite distinct from that conformed to by numbers two, four, six, eight, etc. The lapse of time, in fact, from an even to an odd minimum proved to exceed, in November, 1891, the lapse of time from an odd to an even minimum by the startling amount of 9 hours 42 minutes 55 seconds! Not these discrepant intervals, then, but their appreciably constant sum, represents the circulatory period of the mutually eclipsing stars. Since, moreover, they run through corresponding phases twice in each revolution, they must stand at practically the same level as regards light-giving; while the marked inequality with which the phases divide the period amounts to a demonstration that the path pursued is an ellipse, the major axis of which, although lying in the same plane, makes an angle with the line of sight. The disclosure of these peculiarities has been much hampered by the circumstance that successive minima, being separated by a *mean* interval of a day and a half, cannot, as a rule, be watched by the same observer. The various sets of data refer, accordingly, to odd or even series, the strict comparison of which could alone show the true character of the star.

The amplitude of each phase is three-quarters of a magnitude. In other words, just half the light is temporarily cut off. This is as much as to say that the eclipses are total. For if they were partial (as are probably those of S Antliæ), we should still receive the full light of the eclipsing body plus a fraction of its companion's light; so that their combined rays would be diminished each time by less than one-half. And the identical character of successive eclipses implies, not only the agreement of the stars in lustre, colour and bulk, but the exact coincidence of the plane of their orbits with the line of sight from the earth.

These orbits are perfectly similar ellipses traced out in opposite directions round a common focus, also necessarily the common centre of gravity of the moving bodies, which are presumably twins, as in other respects, so also as regards mass. If this be so, the ellipses they traverse agree not in shape only, but also in size. Now it is scarcely necessary to explain that stars forming an undisturbed binary combination are always two right angles apart. They are situated at opposite ends of a right line passing through the centre of gravity, and at distances from it inversely as their masses. But this line, unless it should happen to coincide with the major axes, divides the orbital ellipses unsymmetrically. The section on the periastron side is both smaller, and is traversed at a more rapid rate, than the apastron section. Thus, if the stars occult one another (as viewed from the earth) a short time (say) after their nearest approach, they cannot again fall in with our visual ray until they have slowly wended their way round the far sides of their orbits. Alternating phases are thus anticipated and retarded, the disparate intervals taken together representing a single period of revolution a little short of three days in length.†

But while their sum is constant, their difference is very far from being so. It amounted in 1886 to about three hours and a half; it reached, in November 1891, nearly nine hours and three-quarters. The rapid growth of the inequality is thus positively ascertained, and it may well be that the inclined balance is by this time in course of restoration. M. Dunér's explanation of these changes, although given under reserve, and needing confirmation, is of great interest and promise. He supposes that the line of apsides of the eclipsing stars revolves under the influence of an invisible perturbing body, just as the lunar apogee progresses through the disturbing action of the sun. Obviously, when the line in question is pointed towards the earth, there can be no discrepancy between the light-periods, the eclipses taking place symmetrically at apastron and at periastron. This condition prevailed, according to M. Dunér's calculations, a short time before the recognition in 1886 of the star's variability in light. The inequality so fruitfully discussed by him then began to develop, and seemed likely to reach a maximum in seven or eight years. This should occur when the parameter of the two orbits coincides with the line of sight—when the stars, that is to say, come to be eclipsed at opposite ends of a line drawn through the common focus at right angles to the major axis. This arrangement gives the greatest possible diversity of minimum-epochs, because the stars, in order to reach the points of eclipse, traverse by turns the entire periastron, and the entire apastron sides of their orbits. Or, putting it otherwise, we may say that the period of revolution is divided into two equal periods when the ellipses traversed lie lengthwise towards the earth, but into two unequal periods when they are any

* *Astr. Nach.*, No. 3091; "Sur les élements de l'étoile variable Y Cygni," communicated to the Academy of Sciences of Stockholm, September 14th, 1892.

† The precise duration is 2 days, 23 hours, 54 minutes, 43·26 seconds (Dunér).

otherwise situated, the inequality reaching a maximum when the same ellipses lie right athwart the visual ray.

The fundamental part of M. Dunér's theory of Y Cygni may be accepted without the smallest hesitation. His research leaves no doubt that the star really consists of two equal components describing, in a period of nearly three days, elliptical orbits situated in the same plane with our line of vision. The application of the spectroscope will give the dimensions of the ellipses in linear measure, whence the mass of the system can be at once deduced. And this unconditionally, because the stars being both bright, their relative velocity—if not their separate absolute velocities—can be determined directly from a photographic plate, while the mass of a bright and dark combination such as Algol can be fixed only on some precarious assumption regarding mean density.

The striking inequality between the alternate light-periods of Y Cygni is then fully explained by the ellipticity of their orbits; while the view that the changes in that inequality are due to a revolution of the line of apsides, although highly plausible, must be regarded as still on its trial. A comparison during the next few years of the predicted and observed dates of minimum ought to prove decisive as to its truth; and the test will be made more stringent if the spectrographic method can be satisfactorily turned to account. For differences in the velocities of the stars in the line of sight, at the elongations preceding alternate minima, should, on this hypothesis, correspond strictly with the varying time-intervals separating the minima, and should disappear with their equalization.

A further criterion is provided by the duration of the eclipses, which, by the nature of the case, must depend upon the quicker or slower movement of the stars. When, accordingly, owing to the line of apsides being pointed towards the earth, they occur by turns at apastron and periastron, the phases at successive minima must be considerably lengthened out and hurried up. In intermediate positions of the line of apsides, moreover, the phases should progress unsymmetrically, the loss of light being retarded at one side of the orbit, the recovery of light at the other.

These irregularities have not yet been definitely observed. They may, however, eventually serve to measure the eccentricity of the ellipses pursued by the components of Y Cygni. And the same element is of course involved in the extent of opposite deviations from the mean epoch of what we may call complementary minima. M. Dunér has indeed already shown that the eccentricity must exceed 0·1, while falling short of 0·2. It would then be small for a telescopic binary, although it appears large for a spectroscopic revolving pair. On the basis of Dr. See's theory of the growth, through an effect of tidal friction, of stellar orbital eccentricity, the stars of Y Cygni can be inferred to be much more widely separated and materially further advanced in development than the components of Algol. And since the period of both systems is nearly the same, the former ought to prove greatly more massive than the latter, its inferiority in brightness being probably due to its much greater distance from the earth.

Satisfactory progress has now been made towards investigating the inequalities of two Algol-variables. The results are noteworthy, both for their likeness and for their unlikeness. A third sensibly dark body appears to be included in each combination, and in neither has any evidence been gathered of variation in the circulatory period of the occulting pairs. But the phases of Algol are believed to be affected by a light-equation consequent upon revolution in a wide orbit; while the irregularities conspicuous in those of Y Cygni depend upon their unsymmetrical relations to the elliptical paths of the mutually eclipsing pair. Moreover, the irregularities themselves are subject to change, probably through a revolution of the apsidal line, with the position of which they are intimately connected. Here, then, the presence and power of a disturbing body appear to be betrayed. But the unseen third member, if really there, must form a revolving system of a higher order with the close pair. And the plane of the large orbit is unlikely to deviate widely from that of the small ones. If this be so, however, the eclipses of Y Cygni must show the effects of a light-equation similar to that of Algol. They have yet to be detected, and may prove inconsiderable. They are almost necessarily so, if the mass of the bright stars be large as compared with that of the dark body which is reasonably supposed to influence their motions.

Dr. G. B. Longstaff, in an interesting paper on "Rural Depopulation," read before the Statistical Society, brings together evidence to show that the flow of population from rural districts to towns has been taking place not only in the United Kingdom, but also in France, Germany, Norway, Austria, Hungary, Switzerland, Italy, Spain, Canada, the United States, Victoria, and New South Wales. The rural depopulation amounts, as a general rule, only to a small fraction of the initial population, while the towns and urban districts have been increasing in population more rapidly than the whole community. Thus the total loss of population in the Welsh counties varies from 0·9 per cent. in Carnarvon to 4·0 per cent. in Flint and 16·7 per cent. in Montgomery. Dr. Longstaff shows that the phenomenon of rural depopulation is not due to any faulty system of government, for it is as prevalent under republican institutions as under military despotisms and constitutional monarchies. It does not seem to be due to any system of land tenure, for it is as marked in France as in England, and under the land systems of the United States and Canada, as under those of the continent of Europe. Freeholds and leaseholds are alike affected; large holdings and small. The peasant proprietor of France, on his much treasured scraps of land, feels the impulse no less than the yeoman of Ontario. Dr. Longstaff conceives that many causes contribute to the flow of the rural population into towns. Agricultural implements, waggons, tools, which were formerly made in the village smithy, are now more cheaply made in the larger manufacturing towns. In the last century locomotion was slow, inconvenient, and expensive; it is now rapid and cheap. Men, by the press, learn where there is a demand for labour, and they easily migrate to it. The dream of the free-trader is fast being realized—we are learning to do in each place that for which each place is most advantageously circumstanced; and, above all, the towns, with their gas and life, and excitement, possess greater attractions than ever to the countryman.

Mr. Ernest Hart was emphatic upon the nature of cholera before the British Institute of Public Health. For all practical purposes he asserts cholera is an exclusively water-carried disease, and caused only by water poisoned from human sources. "You may eat cholera and drink cholera, but you cannot catch cholera." He traces all cholera to Mecca, which he styles the "nursery of cholera," and he makes a series of suggestions to meet the dangers to the world arising from the Mahommedan pilgrimages thither.

THE GREAT LUNAR CRATER COPERNICUS.

By A. C. RANYARD.

THE scale of the lunar craters, as compared with the little planet on which they are found, will probably be best realized by a comparison with terrestrial objects. If the moon could be cut in half, and one of its hemispheres placed upon the earth's surface without altering its shape, it would form a dome-shaped mountain about a thousand and eighty miles high, the circular base of which would about correspond in size with the western hump of Africa comprised between the Gulf of Guinea on the south and Morocco and Algiers on the north.

The great crater Copernicus, the photograph of which we are about to examine, is fifty-five miles in diameter; so that if London were situated upon its southern edge, Cambridge would lie within its northern border. This great crater is only the central region of a district more than five hundred miles in diameter which was evidently violently disturbed by the forces that built up the central ring; for stretching in all directions around the crater will be noticed a series of curiously curved and branching whitish rays, the connection of which with the crater as a centre is unmistakable, although they do not radiate from it in straight lines like the streaks diverging from the crater of Tycho.

FIG. 1.—Copernicus at Sunrise.

Copernicus, in spite of its gigantic size, presents many analogies to terrestrial volcanoes. It is not quite circular in outline, but the craters of many terrestrial volcanoes are not circular, and are sometimes distinctly polygonal. In Plate I. a string of little craters will be noticed on the western slope of Copernicus, midway between the great crater and Eratosthenes (110).

Many similar strings of little craters are found around terrestrial volcanoes, usually marking a line of fissure which can sometimes be distinctly traced. Thus Prof. Judd, in his book on "Volcanoes" in the International Science series, states that during the eruption of Etna in 1865 a line of eight scoria cones formed along a fissure on the flanks of Etna. Similar lines of craters have at times formed on the sides of Vesuvius, and a study of the sections of volcanoes dissected by denudation affords convincing evidence that volcanic cones generally originate upon lines of fissure. The string of little craters between Eratosthenes and Copernicus should be examined with a magnifying-glass; they are best seen on Plate I., but can be traced on Plate II., though a photographic defect in this plate partly obliterates the crater of Eratosthenes. Two strings of smaller craters may be traced branching from the main stream, which extends along the flank of Copernicus for a distance of more than one hundred miles, and then crosses the Apennines in a valley or gap between Eratosthenes and the rugged range of the Carpathians which lies to the north of Copernicus. After crossing the Apennines it debouches on to the Mare Imbrium at the head of a curving white ray, or lava stream, that runs for more than three hundred miles over the Mare Imbrium, reaching far beyond the craters Timocharis (121) and Lambert (122).

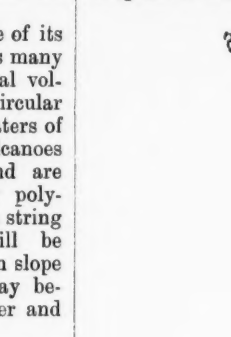


FIG. 2.—The Lunar Carpathians.

FIG. 3.—Ray from Copernicus.

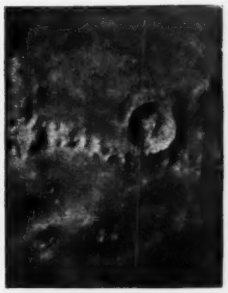
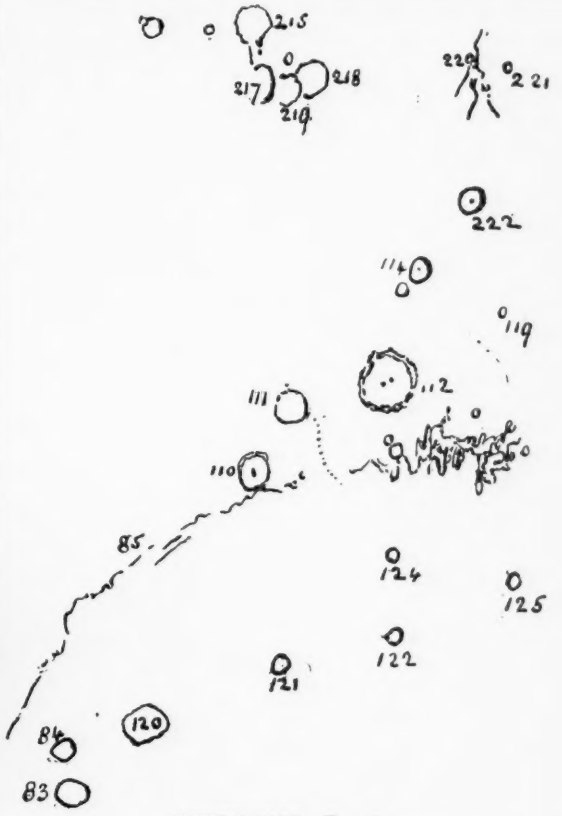


FIG. 4.—Eratosthenes, and streaks from Copernicus.

The question whether this whitish curving ray and the other similar rays which radiate from Copernicus correspond to streams of liquid matter which once flowed from the crater, or whether they are mere discolorations of the surface which follow the course of fissures in the lunar crust, is one of very great interest, and I would invite the reader to spend a few minutes in carefully examining the course



INDEX MAP.—FIG. 5.

83. Aristillus.	119. Hortensius.	217. Parry.
84. Autolycus.	120. Archimedes.	218. Bonpland.
85. Apennines.	121. Timocharis.	219. Fra Mauro.
110. Eratosthenes.	122. Lambert.	220. Riphæan Mountains.
111. Stadius.	124. Pytheas.	221. Euclides.
112. Copernicus.	125. Euler.	222. Landsberg.
114. Reinhold.	215. Gueriké.	

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of some of these rays. If they correspond to lava streams, it will be evident that the lava must have been in a very liquid condition when they ran over the plain; but they do not seem to have run into valleys forming lakes of lava, or to have spread out at their ends like terrestrial lava streams when they reach a level area.

Some of the streaks appear to extend across the ridge which stretches southward from Eratosthenes (see Fig. 4). It may be argued that this ridge may have been raised after the epoch when the lava flowed down from the crater of Copernicus. But a similar assumption can hardly be made with regard to the two great rays, one of which crosses the Apennine range close to Eratosthenes, and the other of which crosses the western end of the Carpathians; for if these ranges, which form the border of the Mare Imbrium, had been raised after the era of the lava flows from Copernicus, the lower ends of the lava streams, where they run over the plain, would have been obliterated by the molten sea which levelled the Mare Imbrium.

These long rays cannot be much raised above the level of the surrounding surface, for they do not throw any recognizable shadows while the sun is rising. They have hazy, nebulous edges, and both sides (that towards the sun and that away from the sun) seem equally soft and indefinite; on the other hand, the smaller forking streams which appear to have run down from the south side of the crater throw distinct shadows. One is therefore led to conclude that the long white rays stretching from Copernicus, like those which radiate from Tycho, are merely surface markings, and that they probably follow the lines of volcanic fissures, the whitish colour on either side being produced by some exhalation which has issued from the fissure, and has been precipitated on the surface near to the vent.

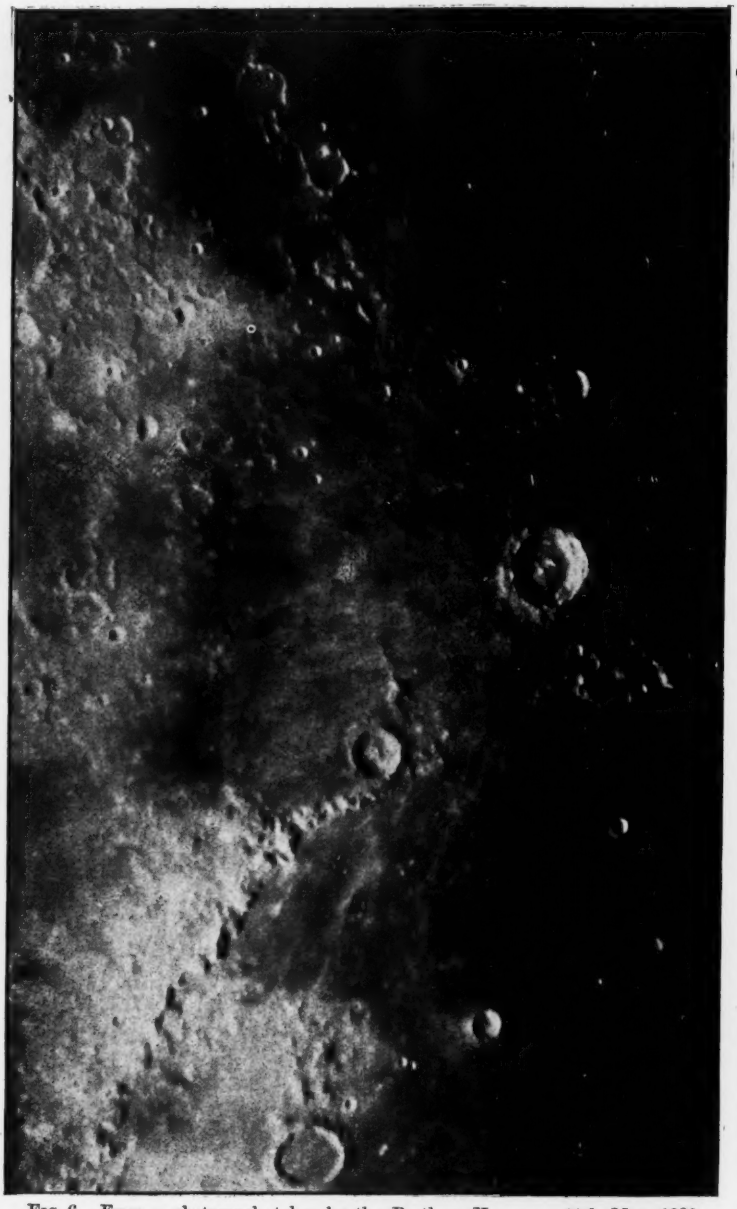

FIG. 6.—From a photograph taken by the Brothers Henry on 28th May, 1890.

It will be noticed on comparing Plates I. and II. that the central regions of these rays are the brightest, and that they decrease in density or whiteness on either side, as might be expected if vapour issued from a narrow vent running along their centre. Thus, if water vapour issued from the vent, it might, on reaching the cold surface, be deposited as snow or hoar-frost on either side, the amount of the deposit being greatest close to the vent. In connection with this assumption it should be borne in mind that, owing to the small intensity of lunar gravity, evaporation must take place more energetically for any given change of temperature at the moon's surface than at the earth's surface.

Thus, from laboratory experiments it is known that the elastic force of water vapour at a temperature of − 32° Cent., is such that it will raise the mercury in a barometer through about a third of a millimetre (0·32 mm.), while at a temperature of 0° Cent. it raises the mercury through more than 4½ millimetres (4·6 mm.). This increase of pressure is independent of the pressure of the atmosphere or other gases. It cannot reasonably be doubted that water vapour would behave in precisely the same way upon the moon as it does here, but in order to raise the pressure of the lunar atmosphere by any required amount, about six times as much water vapour would need to be evaporated into the lunar atmosphere as would need to be evaporated into the earth's atmosphere, where gravity is six times as great. The pressure of water vapour is a physical quantity dependent on the energy of the molecules, and it could be made to depress or raise a spring balance. But the depression of a spring balance which would raise a column of mercury 4 millimetres on the earth would raise a corresponding column about 24 millimetres on the

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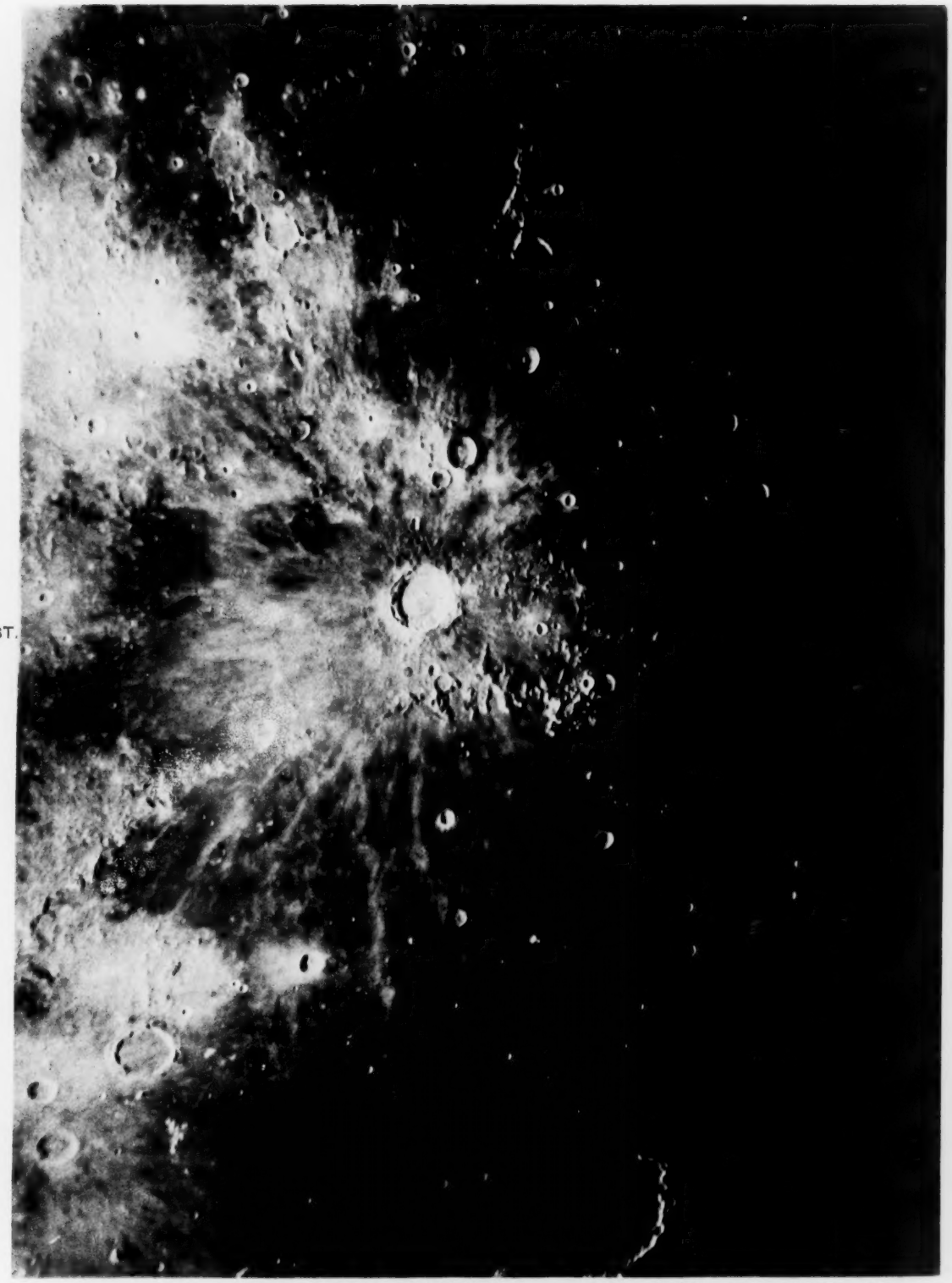
WEST. EAST.

Plate I.—THE REGION AROUND COPERNICUS, AS SEEN WHEN THE MOON WAS 240 HOURS OLD.

Reproduced on about the same scale as the original negative, taken at the Paris Observatory by the Brothers HENRY on the 28th of May, 1890. An enlarged image was thrown by an eye-piece on to the photographic plate; its scale is about 150 miles to the inch.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

SOUTH.



WEST. EAST.

Plate II.—THE REGION AROUND COPERNICUS, AS SEEN WHEN THE MOON WAS 265 HOURS OLD.

Reproduced from a photograph taken at the Paris Observatory, by MM. PAUL and PROSPER HENRY, on the 29th of May, 1890. The sensitive plate was placed behind an eye-piece which enlarged the image in the principal focus of the 13-inch photographic refractor used in the International Survey of the Heavens.

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moon.* This will, I trust, make it clear that the amount of evaporation for a given rise of temperature is much greater at the moon's surface than here, and it need hardly be remarked that the difference of temperature between the lunar midday and lunar midnight is probably much greater than 30° Centigrade. But the white streaks do not melt away or disappear during the lunar day. It is therefore evident that if they are caused by a snow-like deposit on either side of volcanic vents, the deposit must be thick enough not to be melted during the lunar day, and yet the deposit must be thin enough at its edges to only partially whiten the ground; but this is perhaps possible on a rough surface. I would refer readers who take an interest in the theories as to these bright streaks to a paper published in KNOWLEDGE for May, 1890.

Some of the dark markings on the moon are even more mysterious than the white ones. On examining our plates, they might at first sight be taken for photographic defects, but a close comparison of two photographs shows that many of the smallest dark marks are exactly repeated, and a comparison with other photographs proves that very little change takes place in the appearance of these dark spots when the sun is at different altitudes. Take, for example, the curious dark spot on the Mare Imbrium in the fork of the ray between Eratosthenes and Archimedes. It looks like the half of an elliptic crater surrounded by a black line, with an intensely black spot at its southern end. If this marking, as shown on Plates I. and II., is compared, very little doubt will be entertained as to the real existence of its smallest details. See also the two dark and two lighter lines across the floor of the crater of Archimedes, and examine the numerous small black tree-like markings on the southern and eastern sides of its elliptic ring; they look as if small dark-coloured lava streams had overflowed from the crater and spread out at its base.

FIG. 7.—A deeper-etched block from the same photograph as that reproduced on the opposite page.

There are many similar dark markings round other craters—see, for example, on Plate II. the curious dark tree-like structure to the north-east of Copernicus reaching almost from the rim of the crater to the spurs of the Carpathians; and there are other somewhat similar markings on a still larger scale extending from the southern rim of the crater towards the south and west, to a distance of nearly double the diameter of the crater. These dark markings, unlike the bright rays which diverge from Copernicus, spread out at their ends, and they are connected with the region about the crater by comparatively narrow streams. Whether they correspond to streams of dark-coloured lava which once flowed from the crater, or to drainage areas from the high ground—they are on an enormous scale compared with similar terrestrial phenomena. A river like the Thames would appear as a very narrow meandering line beside them, so that it seems difficult to conceive of them as the drainage areas from hot springs. But if lunar eruptions are, like terrestrial eruptions, accompanied by a great evolution of steam which rapidly falls as rain, thickly charged with volcanic dust, vast rivers of mud may have flowed down and discoloured the surface during the erup-

* This relation between the force of gravity and the amount of evaporation is probably the cause of the intense energy of the evaporation phenomena which are observed when a comet approaches the sun. The pressure of an atmosphere of vapour, about a small body like a swarm of stones, must be so small that the whole of any volatile substance would, with a small increase of temperature, be driven off before the pressure corresponding to saturation is reached.

tions of this great volcano. If this theory affords the true explanation of these dark markings, it would follow that in this region of the moon the colour of the lunar surface is not masked by snow or other white deposit which is being continually deposited and evaporated.

If the reader will examine Plate II., he will see just to the north of Timocharis a curious narrow dark circle with a dark centre. After having made sure of this marking on Plate II., he will be able just to recognize the southern half of the circle on a good print of Plate I. It would almost seem as if we had here a section of a volcano dissected by denudation, or the relic of a crater and its volcanic throat which had been cut off or melted down when the Mare Imbrium was surfaced. We have evidently much to learn from these mysterious dark markings.

FIG. 8.—Archimedes and the smaller Crater Timocharis.

Terrestrial volcanoes will sometimes pour out a dark-coloured lava at one eruption and a grey or whitish lava at the next. The colour of the lava seems to depend on the character of the rocks melted at no great distance beneath the surface, for if the lavas all came from one general reservoir at the centre of the earth we should expect them all to be similar in character. And if upon the moon we were to find lavas of different colours, we might take it as evidence that the moon is either stratified or formed of different materials in different parts.

FIG. 9.—Copernicus, showing dark streams from crater.

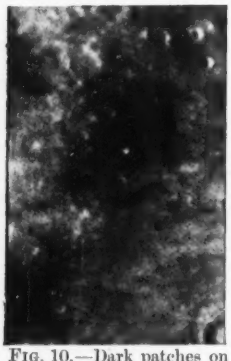


FIG. 10.—Dark patches on the western slope of Copernicus.

There are no very striking differences of colour or even of tint to be detected on the moon, but there are very striking differences of whiteness of the lunar surface, and it becomes a very interesting question to determine whether these differences of whiteness are really due to differences in colour of the lunar rocks, or whether they are due of something which covers the lunar surface in some places and leaves the dark rocks exposed in others. Thus, as has been suggested, the dark regions might be caused by the action of warm springs, which on the earth, always accompany volcanic action. But even if we are ready to conceive of warm springs so copious as to affect areas as large as those corresponding to the streams which seem to have flowed from Copernicus, it seems improbable that warm springs could affect the colour of large areas such as the dark patches on the western slope of Copernicus or the great Maria. As a general rule, plains and low-lying ground upon the moon are dark, while the high ground and mountain-tops are white, and some lunar mountains are much whiter than others. This very markedly points to the conclusion that the whiteness is due to something covering the lunar rocks, and that the covering is more thickly deposited on high ground, as snow is on terrestrial mountains.

The dark markings to which attention is here directed are those which retain their relatively dark appearance as the sun rises, and which can still be traced at full moon; they cannot, therefore, be explained as due to rough surfaces, causing an admixture of shadow that darkens the natural tint. The narrow dark line between the craters Birt and Thebit, in the top left-hand corner of Plate I., is clearly due to a shadow, for it becomes narrower as the sun rises, and is ultimately lost sight of.

FIG. 11.—The Riphæan Mountains.

The curious dark spots on the floors of many lunar craters, and markings like that to the north of Timocharis, however, point to the conclusion that there are striking differences in the light-reflecting power of areas which appear to correspond with lunar volcanic formations, and they further point to the conclusion that there is a real difference in the colour of the lunar rocks, or that there are local differences of temperature, or other local causes corresponding to such formations, which affect the covering that masks the true colour of the lunar surface. But it must be remembered that differences of colour of the lunar rocks, if conclusively proved to exist, would not prove that the rocks were different in composition, for differences of tint may be due to weathering action; thus, many terrestrial lavas when first formed are black, but they subsequently become reddish or brown.

Science Notes.

The mass of the earth, as re-determined by M. Alphonse Berget, is $5{\cdot}85 \times 10^{27}$ grammes, its density 5·41.

The *Lancet* refers to the confirmed "stoop" which has already been manifested by cyclists. The dorsal curvature posteriorly, which used to be rare in boys under fourteen years of age, is now very frequently met with, particularly among those bicyclists whose spinal column is developing more rapidly than the ligaments and muscles. The use of Indian clubs is recommended.

A novel kind of cab has lately been tried in Berlin. In appearance it is not unlike a large bath chair with two seats, and is propelled by a petroleum-naphtha motor. It has three wheels, and carries only two persons, including the driver. The motor is of nearly two horse power, and produces, on good roads, a speed of about eleven miles an hour.

It is proposed to utilize peat moss, and possibly other vegetation, as a source of alcohol, by first converting its cellulose into sugar. This change may be effected by heating the vegetable substance to 115-120° C. with dilute sulphuric acid. The expressed liquor is then fermented with yeast. In this way from 62 to 63 litres of alcohol may be obtained from 1000 kilos of dried turf.

Sir J. B. Lawes recently received, through the India Office, a consignment of phosphates from Madras, with a view to their commercial value being ascertained. The specimens are well-formed nodules, with a nearly smooth buffish coat, and internally appear very pure. Unfortunately, they show no traces of fossils. They come from a region where there are both cretaceous and eocene beds.

The place having the lowest mean temperature in the world is Werkojansk, in North-Eastern Siberia. A temperature of —88° Fahr. has been registered at that cold spot, and the mean minimum is – 61° Fahr. The Colorado River Desert affords an example of a climate of extremes, for the atmosphere has there shown a maximum of 120° Fahr., and the annual range of temperature is 200° Fahr. When this is compared with the range of temperature experienced in London it becomes evident that we have much for which we should be thankful.

A rival product to celluloid, but without its disadvantage of excessive inflammability, has been described by Messrs. Cross, Bevan, and Beadle. Alkaline thiocarbonates of cellulose are obtained by treating that substance with a strong solution of caustic alkali, and subsequently exposing to the vapour of carbon disulphide. The result is a swollen mass of bright yellow colour, the solution of which has an enormous viscosity and from which the cellulose may be regenerated by means of common salt or alcohol. The cellulose is obtained in its new form as a gelatinous hydrate, and the degrees in its gradual regeneration are marked by an increasing tendency to form an insoluble jelly. It is suggested that it will be available to technologists for such purposes as an adhesive substance, for sizing and filling textiles, for producing casts and moulds, as a paper indestructible by water, for photographic films, and for numerous other purposes.

In the *Revue Générale des Sciences* (No. 11) there is an interesting summary of the general progress of bacteriology by Dr. P. Achalme, after which the pathogenic activities of *streptococcus*, characteristic of erysipelas, are particularly discussed. The varying character of the action of this microbe in various media, and according to the nature of the previous medium, and with variations in the method of transporting and of the region of inoculation, are dealt with at length. The virulence and even the nature of the influence exerted are profoundly affected by the previous pathological condition of the subject. Affections connected with streptococcus are always particularly severe with sufferers from diabetes and Bright's disease, and erysipelas upon the face is a frequent appearance in the later stages of hepatic disease. MM. Roux and Yersin have shown a reciprocal exaltation of virulence between the bacillus of diphtheria and streptococcus, and a large proportion of the eruptive phenomena of scarlatina and other affections are "streptococcic." Dr. Achalme uses the term microbic "symbiosis" for such morbid conspiracies. He concludes by insisting that the narrow doctrine of specific microbes must be replaced by an admission that "a plurality of morbid effects may be produced by one microbe, and that a plurality of microbes may engender the same symptomatic complex."

Some important results have recently been obtained by Heider, who has been experimenting with disinfectants at higher temperatures and testing their effects on bacteria. In the majority of cases the bactericidal action is markedly increased by raising the temperature. Hot or even boiling solutions should be used for killing spores; a little of a hot solution goes a long way.

The *post-mortem* excitability of nerves and muscles has been shown by M. A. d'Arsonval to continue much longer than is commonly supposed, and during the *rigor mortis* condition. This he has demonstrated by means of the myophone, an arrangement of the microphone to detect small muscular contractions. Muscular excitability was shown to exist in a rabbit ten hours after death.

The announcement of fossil relics of colossal corkscrews from the miocene beds in Sioux County, Nebraska, is suggestive of burlesque. The remains in question are described by Mr. E. H Barbour in "University Studies," published by the Nebraska University. The spire of the corkscrew is from two to nine feet in length, and invariably vertical, and there is always a horizontal transverse piece below answering to the handle and about three feet in length. The ranchmen have given these remarkable forms the name of "Devil's Corkscrews,' a title Mr. Barbour would preserve in the decently-veiled form of *Daimonelix*. He regards them as fossil sponges, but the occurrence of a well-preserved rodent skeleton in the stem of one suggests that they are after all simply filled-up burrows. The tunnels of some species of Thomomys, it may be noted, are spiral.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE EFFECT OF THE ATMOSPHERE OF MARS ON THE TEMPERATURE OF THE PLANET.

To the Editor of KNOWLEDGE.

SIR,—Since writing my letter "On the Formation of Clouds in the Atmosphere of Mars," I have made a rough calculation as to the effect of such an atmosphere on the temperature at the surface. The result surprised me, and, if correct, must considerably modify the opinion expressed in the last paragraph of that letter as to the dampness of the atmosphere. I have, however, considerable doubt as to its correctness, and would like an independent opinion on the subject.

I assume that the atmospheres of Mars and the earth are about equally damp. Let us take four miles as the average height of clouds on the earth, and twenty miles as the corresponding height for Mars.

Let H be the amount of solar heat which falls in a given time on, say, one thousand square miles of the earth's surface. Were it not for the aqueous vapour in our atmosphere, this heat would be all radiated away again, and lost in space. Suppose that when this quantity H of heat is traversing the atmosphere on its outward journey, a quantity aH is absorbed by the aqueous vapour. Then this quantity aH of heat represents the amount which goes to raising the surface temperature, or as we may word it, the amount *conserved*.

Let G be the quantity of solar heat which falls in the same time on one thousand square miles of Mars' surface. Then, when this heat is being radiated away (the atmospheres being supposed equally damp), a quantity aG is absorbed in the first four miles of atmosphere, and $(1-a)$

G passes through. Of this, $a(1-a)$G is absorbed in the second four miles, and $(1-a)^2$G passes through. Proceeding in this way, the heat which finally escapes from the fifth four-mile layer is $(1-a)^5$G, and therefore the total heat absorbed in the atmosphere is $a(5-10a+10a^2-5a^3+a^4)$G.

We do not know what a is exactly; however, we may be pretty sure that it represents a fraction which is not very large nor yet infinitesimally small. Consequently, we may take the above as probably between $4a$G and $2a$G.

We know that G is about ·4H.

So, if the heat conserved on the earth be aH, that conserved on Mars is probably between $6a$H and ·$8a$H.

This would account for a surface temperature not very different from our own, but probably a little *warmer*. Since Mars is probably *colder* than the earth, the conclusion I draw is that the atmosphere is somewhat drier than ours.

Of course the figures I took, four miles and twenty miles, are uncertain. But the general argument does not involve the exact figures; the gist of it is that in estimating the effect of the atmosphere of Mars on the temperature, the great *thickness* of the absorptive stratum must be taken into account, and will cause the atmosphere to conserve much more of the incident heat than ours does.

The same line of reasoning applied to the planet Venus would make it excessively hot.

J. R. HOLT.

[I agree with Mr. Holt that the density of the aqueous vapour present in the lower strata of the atmosphere of Mars will depend upon the temperature of the Martial surface, and not upon the density of the Martial atmosphere, for at any given temperature as much aqueous vapour rises into a vacuum as into a dense and dry atmosphere. With gravity at the surface of Mars equal to only 39 per cent. of gravity at the earth's surface, the density of the Martial atmosphere will be halved at a height about two and a half times as great above the surface of Mars as the height above the earth's surface at which the density of the earth's atmosphere is halved; consequently, an atmosphere of aqueous vapour of any given density at the surface of Mars will, if it is not precipitated into cloud or ice particles, extend to about two and a half times (not five times) as great a height above the surface of Mars as it would extend above the surface of the earth,* and any absorption due to aqueous vapour would correspond to the absorption of a layer of similar density two and a half times as thick above the earth's surface. But if I understand rightly, Prof. Langley's bolometer observations have thrown great doubt upon the theory that aqueous vapour transmits solar heat while it absorbs the non-luminous heat of long wave-length radiated by the earth's surface; and it will be remarked that if Mr. Holt's theory held good, the moon's surface, with lunar gravity equal to only about a sixth of terrestrial gravity, ought to become in the course of the lunar day much hotter than the earth's surface, but if the observations of Profs. Langley, Very, and Boys are to be relied upon, this is not the case.—A. C. RANYARD.]

To the Editor of KNOWLEDGE.

SIR,—Would not the establishment of a "Scientific Review of Reviews," published monthly, and including summaries of the transactions of the learned societies, be the best method of solving the problem you refer to in the August number of KNOWLEDGE (p. 148)? A mere index, without some sort of indication as to the drift and bearings of the article in question, would hardly lessen the difficulty very much. Such a review would have to be edited by one of those you term scientific "scholars," assisted by a strong staff of specialists and correspondents. The necessity of keeping the review within reasonable limits would prevent its injuring the already existing magazines by doing more than just summarize their articles. So many of our greatest feats in science have been achieved by private individuals that it would be a great pity to intrust so important an undertaking to any department of the Government.

Yours faithfully,

Malvern. H. ST. A. ALDER.

[Such a review would certainly not pay commercially. The work would probably be most satisfactorily done if the various learned societies could induce specialists to contribute an index of papers in their own special departments. *Précis* of scientific papers, similar to the head notes of cases published in Law Reports, would be most difficult to prepare.—A. C. R.]

To the Editor of KNOWLEDGE.

DEAR SIR,—If I might be permitted to make a small criticism upon Dr. Anderson's interesting article in the July number of KNOWLEDGE, it would be with reference to the sentence:—"It is perhaps too late now to restore to θ its ancient style and title of Achernar, but α at least should be made to yield up its usurped honours." But α Eridani is really "the last star in the river" as we know the constellation, so that one hardly sees why it should be deprived of the name Achernar, which has that meaning, because Ptolemy called another star (our θ Eridani) "the last in the river"; it being the last in the stream which was visible in his latitude. The proper thing, it appears to me, would be to retain Achernar as the name of α Eridani, and to call θ Eschatos or Ptolemy's Eschatos.

It is certainly very remarkable that in his time (and for centuries afterwards) there should have been a star of the first magnitude at the extreme end of Eridanus as visible in Alexandria, and that there should also be a star of the first magnitude at the extreme end of that river as extended by observations made further to the south in more recent times, whilst Ptolemy's first should have faded down to the third magnitude. But there are more strange things in heaven and earth than our philosophy dreams of, and there seems no escape from the conclusion. The nature of the variability, then, of θ Eridani would seem to be almost unique; for it is not a case of gradual diminution through the centuries. Ptolemy, Al Sûfi and Ulugh Begh found it of the first magnitude; Halley, about two centuries after the latter, observed it of the third magnitude, at which it has remained ever since. Gould, in the *Uranometria Argentina*, registers 2·6 as the precise magnitude when he formed his catalogue.

But there is a further difficulty connected with it, which is this. Bayer, in the tables accompanying his constellation maps (published in 1603) assigns to θ Eridani its modern magnitude, the third. How did he obtain his knowledge of this, which carries back the change of magnitude to nearly a century before the time of Halley? Tycho did not observe it, for the best of all possible reasons; and it would almost seem as if Bayer took more trouble about some of his data than has generally been supposed. His α Eridani (marked of the first magnitude) is undoubtedly that in the far south which is now commonly called

* It follows from this that about two and a half times as much aqueous vapour would, for any given temperature, be evaporated from the surface of Mars as from an equal area of the earth's surface.

Achernar—a name, in my opinion, which it should still retain.

I may here point out an *erratum* in the B. A. C., which has not, I think, been noticed before. It affixes the letter *a* not only to Achernar but also to a star of the fourth magnitude, numbered 12 in Flamsteed's list of the stars in Eridanus. The source of this mistake can be traced; it evidently arises from the circumstance that that star is called *a* Fornacis by Lacaille.

Yours faithfully,

Blackheath, August 16th, 1893. W. T. LYNN.

P.S.—In my letter to you of the 18th July (printed in the last number, p. 154), the Greek word ἑστία, corresponding to the Latin *focus*, is advertently spelt with the smooth breathing. If a word were coined from it similar to "perihelion," it would be "perihestian," but there would be many objections to such a word. Mythologically, Ἑστία corresponds to the Latin *vesta;* and, moreover, it has never been used in a mathematical sense, like *focus*, which (as I pointed out in my "Celestial Motions") is a term transferred from optics to mathematics and astronomy. "Perigee" (which surely should be "perigeen") and "perihelion" are too firmly imbedded in astronomical books now to be displaced, and there seems no objection to the more recent "periastron." But, as Mr. Holt points out, this is not the case with some of the hybrid words used in reference to the planets. "Perijove" (if such a word must be used) should be "perizena"; "perisaturnum," in Greek mythology, would be "perikronon."—W. T. L.

To the Editor of KNOWLEDGE.

SIR,—As it would appear from your August number, containing some further reproductions of lunar photographs by the skilful Brothers Henry, that the interesting and as yet hardly-opened study of selenology is likely to continue to occupy your pages a little longer, may I refer back to your number for July last, and to that marvellous photogravure of "the moon when 136 hours old," in order to refer to some little points apparently not yet fully noticed, and which perhaps would have passed unobserved by me but for certain observations and photos made in Melbourne some twenty years ago, when I was in charge of the great telescope.

At this distance in time and space my notes are not available to refer to, but certain appearances have remained indelibly impressed upon my mind, awakened as it then was to the importance of selenology, as furnishing analogies highly useful in the study of our own geology.

In your article on "The Great Plains on the Moon" (July), you remark upon "a curious, narrow, dark line which seems not to be due to any photographic defect. It skirts the high ground on the edge of the Mare (Tranquillitatis) for a distance of more than one hundred miles, and ultimately seems to pass through or over a ridge to the south of Sabine (65)." You then point out another similar but broader line, "skirting the western edge of the Mare Nectaris." The first of these (permit me for convenience* to call it Ranyard *a*) I remember to have seen, and on the photo-plate it is to my eye undoubtedly an imperfectly filled fault or fissure in the substance of the plain, the date being probably subsequent to the formation of Sabine (65), the southern buttress of whose crater-wall it cuts and breaks down in its course. Less distinct, but apparently a similar formation, is that on the west of the Mare Nectaris (Ranyard *b*), which to my eye seems terminated by a minute craterlet, into which several branching creases of the surface also dip and disappear.

You have already observed that such small craters are probably on the line of unseen faults in the lunar crust, since they have a tendency to occur in strings or lines. Your surmise is doubtless correct, since I have seen, in the four-feet reflector, these two things in plain visual connection. And even in the Henry photographs your theory receives good support, since not only does Nectaris *b* end in a craterlet, but Tranquillitatis *a* seems to terminate also in the direction of a well-marked small crater east of Sabine (65); while a southern parallel fault, branching from Tranquillitatis *a* at mid-length, not only cuts but dislocates to the east considerably the southern buttress of Sabine, at a few miles distance, and then disappears towards a low crater in the shadow of the other side. The effect of this whole duplicated fault and dislocation is not only to bear out your view, but, when coupled with the roller-like undulations of the Mare advancing upon Sabine and Arago (63), to give the impression of an extensive disruptive flow of the lava-plateau towards the east, and which had found its southern limit here.

Before leaving this interesting rill, it may be observed that Tranquillitatis *a*, at its western end, also disappears in a craterlet, which may be seen at the northern termination of the mountain ranges forming the buttresses of Hypatia (317); but not before leaving, as a depression in its very bed, a tiny craterlet, at a point a little to the east of where a small pit with a whitish edge (probably also in connection with this "fault") nearly touches its northern edge.

Nearly parallel with this rill and well on the other side of Sabine will be found another fault, of older date than the last, since it is almost effaced on the lower levels of the plain, and entirely so where a low spur of Sabine cuts it near its N.E. end. This fault ends in a well-marked craterlet of very low ring-wall, on the plain between Sabine and Manners (486).

At its other extremity it gradually disappears amongst the partially dislocated and small isolated ridge west of the S.W. extremity of Tranquillitatis *a*.

Northwards, and still upon the Mare Tranquillitatis, there appears a curious scar, straight, and with its steepest edge to the west, and situated on the plain nearly half-way between Sabine and Maskelyne (67), which can hardly be a photographic defect. It is even more distinct than the little crater-pit a short distance further west, and it has a curious parallelism with the meridional scars, creases, or wrinkles which commence in the wall of Sabine and which end somewhat convergently in or near Manners (486), again supporting the theory as to faults and craters. It is difficult to imagine these to be photographic defects, since they appear also in the ring-wall of Sabine, both outside and in, and take there a corresponding curvature. They are probably rents produced by eruptive force in Sabine, and consequently of later date.

West of Arago (63), and in a line due north from Theophilus, commences (again in some minute craterlets or fumaroles) another fault, whose course has been almost obliterated by subsequent fusion or degradation, but which trends, with slightly curving south-westerly course, until it ends in the low wall of Maskelyne (67), a half-sunk crater of apparently older date.

Turning further to the north, we may observe a curious fine bright line, making as it were a continuation of the

* While thanking Mr. Macgeorge for his kindly-intended compliment, I trust he will permit me to change the proposed names in the remainder of his letter to Tranquillitatis *a* and Nectaris *b*, names which seem to me to be decidedly preferable, because they roughly indicate the position of these curious markings, and because it does not seem to me to be desirable to name portions of the moon or planets after living people.—A. C. R.

XUM

bayonet-shaped ridge which issues from the S.W. side of the breached and half-effaced crater-ring of Jansen (66). At first sight it might pass for a photographic scratch, but the way in which it traverses first a tiny crater at the bayonet's point, looping slightly to the crater's shape, and then two sharply defined and larger craterlets well out on the plain—all these, with the "scratch," being in one straight line—leads one to regard it as the raised ledge of a fault or dyke, touched sharply by the morning light.

Fainter still in its course, though still traceable, is another system of rills to which the eye may be guided as follows:—Nearly in the line of Sabine (65) and Maskelyne (67), and lying at about an equal distance west of these, is the southernmost of two small crater-pits; a little to the north of the northernmost of the two commences one branch of the main rill, which the eye can follow downwards until opposite to a low, small, cup-topped hill. A little east of this the branch, with some other still smaller ones, falls into a somewhat wider straight rill, trending N.E. Following this until nearly opposite to a third pit (having a smaller companion a little further west) is the point of junction of another branch rill, which has its rise in some minute flat depressions nearly opposite our starting point, to the south. Leaving this junction, and continuing N.E. on the main rill, we pass—on the left, and quite close at hand—two minute pits in succession, which also join in to our main rill by short channels. A little further, the photo-engraving ceases to mark the course distinctly, but upon the same N.E. line we observe numerous little pits and depressions, which gradually guide the eye to a small crater in the hill-country west of Jansen (66).

Doubtless, by reference to the original photograph, you will be able to check any error in the foregoing, or point out any features which may be called photographic defects.

There are other formations of both plains and mountains which I will not here touch upon, but which all go towards proving the theory as to craterlets being on the line of faults, even when these do not at once strike the eye—and there is also some evidence to show that the larger craters have had to do with the production of these faults, fissures, rills, ridges, and ledges; and all that we can see upon the moon or its photographs tends to make us feel inclined to put aside—at least as chief agent—the projectile theory, the ice theory, and every other but the volcanic theory.

While in a general way agreeing with your observation that the earlier craters "do not present a distinctively rounded appearance, indicating a longer period of weathering," permit me still to say that although few portions of the mountainous regions of the moon show distinct traces of weathering (although on the plains, smoothened and softened outlines prevail in the older parts), yet there are to be found evidences of degradation, of veiling with newer lava and scoriæ, and even of extensive re-fusion from below, sufficient to mark an older date.

To my eye—possibly prejudiced by great telescope observations—Theophilus (319) is very markedly fresher and sharper in outline, especially interiorly, than the older and more degraded Cyrillus (320), upon which it trenches, and this, again, is still superior in definition to Catharina (321). Most degraded and age-softened of all, and, as it were, half re-melted into the crust, is the diffused fourth great crater-ring beyond, with its central twin-crater of somewhat later date. The order of formation would seem to have begun here upon the course of a great fissure, and the disruptive force to have acted in the curved line indicated by Catharina and Cyrillus, ending with Theophilus and Mädler, whose newer and whiter *débris* have freshened the whole combined western slope down to the level of the Mare Nectaris.

Pardon the length of this communication.

Yours obediently,

Riviera, 15th August, 1893. E. F. MACGEORGE.

THE SUN AS A BRIGHT-LINE STAR.

To the Editor of KNOWLEDGE.

DEAR SIR,—In response to your courteous invitation to comment upon Miss Clerke's most interesting and valuable paper in the August number of KNOWLEDGE, I should like to say that the most important point of the paper appears to me to be the emphasis placed upon the singular spectrum of Mira Ceti, with the suggestion for further observations bearing on the questions which it raises.

I may, perhaps, be allowed first of all to differ from one expression in the earlier part of Miss Clerke's paper, viz., the description of the faculæ as "enormously hot; hotter, certainly, than the photosphere." This does not appear to me to be proved to be the case. Faculæ are elevations above the photospheric level. They are subject, therefore, to less of the *general* absorption of the solar atmosphere, that absorption evidenced by the diminution of light near the limb; they are also subject to less of the *selective* absorption evidenced by the Fraunhofer lines. They also have a special luminosity of their own as seen by the reversal of the H and K lines. And yet with all these advantages they are so little brighter than the photosphere that they are ordinarily invisible near the centre of the disc, and are only to be seen near the limb, where the photosphere is seen through a great depth of absorbing atmosphere. It seems to me that, could we view faculæ and photosphere under equal conditions, the probability—indeed, the certainty—is, that the photosphere would shine out as the brighter of the two.

This brings us to the *crux* of the entire problem, for it accentuates the difference between the spectrum of Mira Ceti and that of the sun. In the sun we trace the lines of hydrogen and the supposed lines of calcium to the same distance above the photosphere. The two elements are therefore intermingled, and at the same temperature. Nevertheless, in the region of the faculæ we find the calcium lines, rather than those of hydrogen, bright, whilst Mira gives us the precise reverse.

It seems impossible under these circumstances to adopt the suggestion that in Mira we have an atmosphere of mingled hydrogen and calcium which behaves in an exactly opposite manner, the hydrogen lines being very bright—far up in the ultra-violet, too, sure sign of an exalted temperature—and the calcium lines very dark; *but* the calcium atmosphere eliminating, for the H line of hydrogen, the effect of the radiation of the glowing hydrogen immediately below it. If the calcium, rather than the hydrogen, glows in the faculæ of the sun, ought it not to do the same in Mira?

On the other hand, how can we accept the conclusion from which Miss Clerke tells us "there is no escape"? Is it possible to conceive a star with a photosphere overlaid by a stratum of much more highly-heated hydrogen, and that again by a dense layer of cooler calcium? If the two gases are intermingled in the sun, why not in Mira? What conceivable power keeps the dense, the colder and heavier gas in the upper stratum, and the hotter, lighter gas below?

There are two ways of escape which suggest themselves to me, but neither of which I feel myself free to accept. The first is, that "the continuity of the harmonical progression" may, in the case of Mira, be really broken. That the lines of hydrogen in the spectra of

different stars do not vary equally and simultaneously is obvious, and I cannot therefore regard it as inconceivable that in this instance the H line may be truly missing. The existence of two lines on the one side and of four on the other render it, however, very improbable.

The other suggestion is, that we have to do with two distinct bodies, and that the body giving rise to the bright hydrogen lines lies behind that surrounded by the dense calcium vapour. This, again, for obvious reasons is very improbable. It remains only to confess that at present I see no solution of the difficulties before us, and I think that it is from the intricacy of the problem, and not from any oversight, that the spectrum of Mira Ceti has received so little comment hitherto. Spectroscopists are the more indebted to Miss Clerke for her suggestion as to the next observations to be secured. The more perplexing the problem before us is, the more complete and fruitful will its solution be when we at length possess the key.

E. W. MAUNDER.

ABSORPTION IN THE SUN.

To the Editor of KNOWLEDGE.

SIR,—My article on "The Sun as a Bright-line Star," in the last number of KNOWLEDGE, was written without prepossessions for or against any general theory of solar absorption. My object was simply to draw some inevitable conclusions (as they appeared to me) from certain well-ascertained facts. If the constitution of the "reversing-layer" is largely implicated, the responsibility rests with the facts, not with my inferences from them. But since you, sir, have, in a courteous editorial note, expressed doubts as to their validity, it is necessary to reconsider them.

Following your example, I will take the K-line alone. This quality of radiation comes to us bright from faculæ on the disc of the sun. The vapour emitting it is then hotter than the photosphere: it is, to a still greater degree, hotter than the absorbing stratum, which, because cooler than the photosphere, stops the whole of its light of the same wave-length as K. I say the whole, because the remnant of K-illumination in the solar spectrum comes from the absorbing layer itself, not from the photosphere. The screening action is complete, but the screen is self-luminous. Between this absorbing layer and the faculæ there is, accordingly, a wider difference of temperature than between it and the photosphere. If, then, it arrests all the photospheric light agreeing with K in refrangibility, it should, *à fortiori*, if situated at a higher level than the faculæ, arrest all the K-light derived from them. The fact that, to all appearance, none of it is arrested, evidently relegates the absorbing calcium-stratum to a lower level.

Another circumstance seems equally demonstrative to the same effect. If the chromosphere were enveloped in vapour absorbing and emitting K-light, a line drawn through it to the edge of the sun should be many times longer than a line drawn to the centre of the sun. Hence any action exercised by it upon faculæ should be vastly intensified as regards our spectroscopic view of chromosphere and prominences. Nevertheless, the K-line is scarcely less brilliant in them than in faculæ. Moreover, a calcium-stratum profound enough to render the difference in question negligible, is totally inadmissible. Even if it had a depth equal to the sun's radius, the ratio of the lines penetrating it to the centre and limb of the sun would still exceed one-half; and in this case, the rays emitted by it, showing bright off the sun, should invariably and everywhere attain a height above the limb of 15′.

Passing to the spectrum of Mira, our editor maintains that the absence from it of the bright H-line of hydrogen "cannot be taken as proving that the cool calcium-vapour is above the glowing hydrogen." The absorption by the calcium H of the nearly coincident hydrogen-ray may, we are told, be entirely due to difference of temperature. But how can one gas be cooler than another if they are intermixed, as it is assumed they are, in one and the same locality?

Yours faithfully,

A. M. CLERKE.

[If the gases which absorb the light of the sun's photosphere formed an atmosphere about the sun, it would be impossible to conceive of two kinds of vapour at different temperatures existing in the same region. But we may feel sure that the vapours present in the chromosphere and corona of the sun do not form an atmosphere in which the gases rest in equilibrium or in layers upon one another. With solar gravity equal to $27\frac{5}{4}$ times terrestrial gravity, such an atmosphere, even if composed of hydrogen, could not extend to a height of a few hundred miles without being reduced in density so as to be quite negligible. Thus it may be demonstrated that at a temperature of 2457° Cent. hydrogen would be reduced to a millionth of a millionth of its density at the lower level on rising through a height of 270 miles. We must therefore conclude that the molecules of the gases above the photosphere are moving in long free paths, having been evaporated from solid or liquid particles falling from a cooler region, or that they are derived from prominence streams rushing upward from a lower level; in either case we may have molecules at the same level at very different temperatures, because they are derived from different sources.

I admit that there is an appearance of stratification in the lower and hotter regions of the sun immediately above the photosphere, but I would urge that this can only be an apparent stratification due to the effect of temperature in modifying the general physical condition and the spectrum given out, and that in the stars as well as in the sun there must be a complete mixture of materials; though as we approach the heated centre there will be regions where some of the materials condense into the liquid or solid state, while the rest remain in a state of vapour.

It seems highly probable that similar molecules will always give out or absorb the same wave-lengths under similar conditions, and that they will always condense and vaporize at the same temperature, and at first sight it might seem necessarily to follow that the driving into vapour of different materials would always succeed one another in the same order as we approach a highly-heated body; but there are at least two possible ways in which a variation of the order may be accounted for.

1. Differences in the mass of stars would cause matter condensed in the coronas surrounding the stellar photospheres to approach the heated centre with different velocities, and before complete evaporation falling particles would be carried to different depths or isothermal regions.

2. In stars at different temperatures we may have very different intensities of the explosive action which, in the sun, is continually driving the matter of which the prominences and the corona are composed away from the centre, to cool in the outer regions and fall again. It seems probable that the mass of the star remaining unaltered, the greater the heat the greater would be the velocity of the up-rushes, and incandescent material would be carried into colder regions before it ceased to shine.

In addition to these two causes of variation, stars may not all consist of similar materials, or of materials mixed in the same proportion; but it is evident that this last possible cause of variation will not account for the difference between the spectra of Mira and the sun.

I entirely agree with Mr. Maunder as to the comparative shallowness of the layer about the sun which causes *general* absorption, as compared with that which causes *selective* absorption. It seems probable that the layer causing general absorption is not a gaseous layer, but is a stratum above the photosphere which is rendered partially opaque by the presence of small solid or liquid particles.—A. C. RANYARD.]

THE FACE OF THE SKY FOR SEPTEMBER.

By HERBERT SADLER, F.R.A.S.

SOME magnificent spots have lately appeared on the Sun's disc. Conveniently observable minima of Algol occur at 10h. 11m. P.M. on the 3rd; 7h. 0m. P.M. on the 6th; 11h. 52m. P.M. on the 23rd; and 8h. 41m. P.M. on the 26th. About the end of the month the Zodiacal light is visible in the east before sunrise.

Mercury is a morning star, and is well situated for observation during the first portion of the month. He rises on the 1st at 3h. 40m. A.M., or 1h. 33m. before the Sun, with a northern declination of 14° 46′, and an apparent diameter of 6″, $\frac{7}{10}$ths of the disc being illuminated. On the 3rd he rises at 3h. 48m. A.M., or 1h. 30m. before the Sun, with a northern declination of 13° 57′, and an apparent diameter of $5\frac{3}{4}$″, $\frac{78}{100}$ths of the disc being illuminated. The planet is now at about its greatest brightness. On the 9th he rises at 4h. 25m. A.M., or 1h. 1m. before the Sun, with a northern declination of 10° 30′, and an apparent diameter of $5\frac{1}{4}$″, $\frac{92}{100}$ths of the disc being illuminated. After this he gets too near the Sun to be readily observed. He is in superior conjunction on the 20th. While visible, Mercury describes a direct path through Leo, without approaching any conspicuous star very closely.

Venus is an evening star, but her proximity to the Sun and her increasing southern declination render her rather difficult to observe. She sets on the 1st at 7h. 43m. P.M., or 57m. after the Sun, with a southern declination of 4° 3′, and an apparent diameter of $12\frac{1}{2}$″, $\frac{84}{100}$ths of the disc being illuminated. On the 17th she sets at 7h. 9m. P.M., or 1h. after the Sun, with a southern declination of 12° 0′, and an apparent diameter of 13″, $\frac{79}{100}$ths of the disc being illuminated. On the 30th she sets at 6h. 46m. P.M., or 1h. 5m. after the Sun, with a southern declination of 17° 41′, and an apparent diameter of $14\frac{1}{2}$″, about $\frac{3}{4}$ths of the disc being illuminated. At this time her brightness is about $\frac{35}{100}$ths of what it will be about the middle of January, 1894. Venus is in conjunction with Saturn at 3h. A.M. on the 2nd, Venus being nearly 2° south of Saturn. During the month Venus passes through part of Virgo into Libra, but does not approach any bright star. She will be occulted by the Moon on the 13th, but the phenomenon will not be visible in England.

Mars, Saturn, and Uranus are, for the observer's purposes, invisible.

Jupiter is getting every night more favourably situated for observation. He rises on the 1st at 9h. 21m. P.M., or 2h. 35m. after sunset, with a northern declination of 19° 19′, and an apparent equatorial diameter of 41·0″, the phase on the *p* limb amounting to 0·4″. On the 18th he rises at 8h. 16m. P.M., or 2h. 9m. after sunset, with a northern declination of 19° 24′, and an apparent equatorial diameter of $43\frac{1}{4}$″. On the 30th he rises at 7h. 28m. P.M., or 1h. 47m. after sunset, with a northern declination of 19° 20′, and an apparent equatorial diameter of $44\frac{3}{4}$″, the phase being still perceptible. During the month he describes a very short looped path in Taurus. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon:—A transit ingress of the shadow of the first satellite at 10h. 23m. P.M., on the 2nd; a transit egress of the shadow of the second satellite at 0h. 43m. A.M., on the 3rd; a transit ingress of the satellite itself at 1h. 8m. A.M., and its transit egress at 3h. 25m. A.M. On the 4th a transit ingress of the third satellite at 0h. 51m. A.M. and its transit egress at 2h. 14m. A.M.; an occultation reappearance of the second satellite at 10h. 31m. P.M. On the 5th a transit ingress of the shadow of the first satellite at 4h. 29m. A.M. On the 6th an eclipse disappearance of the first satellite at 1h. 39m. 18s. A.M.; an occultation reappearance of the satellite at 5h. 9m. A.M.; a transit ingress of the shadow of the first satellite at 10h. 58m. P.M. On the 7th a transit ingress of the first satellite at 0h. 18m. A.M.; a transit egress of its shadow at 1h. 10m. A.M.; a transit egress of the satellite at 2h. 29m. A.M., and an occultation reappearance of the same satellite at 11h. 37m. P.M. On the 10th a transit ingress of the shadow of the first satellite at 0h. 58m. A.M.; its transit egress at 3h. 19m. A.M.; a transit ingress of the satellite itself at 3h. 39m. A.M.; and a transit ingress of the shadow of the third satellite at 11h. 13m. P.M. On the 11th a transit egress of the shadow of the third satellite at 0h. 57m. A.M.; an eclipse reappearance of the second satellite at 10h. 23m. 15s. P.M., and its occultation disappearance at 10h. 45m. P.M. On the 12th an occultation reappearance of the second satellite at 1h. 1m. A.M. On the 13th an eclipse disappearance of the first satellite at 3h. 33m. 11s. A.M. On the 14th a transit ingress of the shadow of the first satellite at 0h. 52m. A.M.; a transit ingress of the satellite itself at 2h. 9m. A.M.; a transit egress of the shadow at 3h. 4m. A.M.; of the satellite at 4h. 20m. A.M.; and an eclipse disappearance of the satellite at 10h. 1m. 41s. P.M. On the 15th an occultation reappearance of the first satellite at 1h. 28m. A.M.; a transit egress of its shadow at 9h. 32m. P.M.; and a transit egress of the satellite itself at 10h. 48m. P.M. On the 17th a transit ingress of the shadow of the second satellite at 3h. 34m. A.M. On the 18th a transit ingress of the shadow of the third satellite at 3h. 13m. A.M., and an eclipse disappearance of the second satellite at 10h. 44m. 43s. P.M. On the 19th an eclipse reappearance of the second satellite at 0h. 58m. 39s. A.M.; an occultation disappearance of the satellite at 1h. 13m. A.M.; and its reappearance from occultation at 3h. 28m. A.M. On the 20th a transit egress of the second satellite at 9h. 36m. P.M. On the 21st a transit ingress of the shadow of the first satellite at 2h. 45m. A.M.; a transit ingress of the satellite itself at 3h. 59m. A.M.; a transit egress of its shadow at 4h. 58m. A.M.; an occultation disappearance of the third satellite at 10h. 6m. P.M., and its reappearance from occultation at 11h. 23m. P.M.; and an eclipse disappearance of the first satellite at 11h. 55m. 43s. P.M. On the 22nd an occultation reappearance of the first satellite at 3h. 17m. A.M.; a transit ingress of its shadow at 9h. 14m. P.M.; a transit ingress of the satellite itself at 10h. 26m. P.M.; and a transit egress of its shadow at 11h. 26m. P.M. On the 23rd a transit egress of the first satellite at 0h. 37m. A.M., and its reappearance from occultation at 9h. 45m. P.M. On the 26th an eclipse disappearance of the second satellite at 1h. 20m. 4s. P.M.; its reappearance at 3h. 33m. 57s. A.M.; and its occultation disappearance at 3h. 38m. A.M. On the 27th a transit ingress of the second satellite at 9h. 46m. P.M.; a transit egress of its shadow two minutes later. On the 28th a transit egress of the second satellite at 0h. 1m. A.M.; a transit ingress of the shadow of the first satellite at

4h. 39m. A.M.; an eclipse disappearance of the third satellite at 9h. 7m. 17s. P.M.; and its reappearance from eclipse at 10h. 36m. 27s. P.M. On the 29th an occultation disappearance of the third satellite at 1h. 45m. A.M.; an eclipse disappearance of the first satellite at 1h. 49m. 42s. A.M.: an occultation reappearance of the third satellite at 3h. 0m. A.M.; an occultation reappearance of the first satellite at 5h. 6m. A.M.; and a transit ingress of the shadow of the first satellite at 11h. 8m. P.M. On the 30th a transit ingress of the first satellite at 0h. 15m. A.M.; a transit egress of its shadow at 1h. 20m. A.M.; a transit egress of the satellite at 2h. 26m. A.M.; and its reappearance from occultation at 11h. 33m. P.M. The following are the times of superior and inferior conjunctions of the fourth satellite:—Superior, September 2nd, 9h. 11·9m. A.M., 19th, 2h. 16·2m. A.M.; Inferior, September 10th, 7h. 9·5m. P.M., 27th, 11h. 41·5m. A.M.

Neptune is beginning to be visible, as he rises on the 1st at 10h. 6m. P.M., with a northern declination of 20° 55′, and an apparent diameter of 2·6″. On the 30th he rises at 8h. 8m. P.M., with a northern declination of 20° 54′. He is in quadrature with the Sun on the 5th. He is almost stationary in Taurus during the month.

There are no very well marked showers of shooting stars in September.

The Moon enters her last quarter at 9h. 42m. A.M. on the 3rd; is new at 7h. 5m. A.M. on the 10th; enters her first quarter at 4h. 19m. A.M. on the 18th, and is full at 8h. 23m. P.M. on the 25th. She is in perigee at 10h. A.M. on the 4th (distance from the earth 229,650 miles); in apogee at 2h. P.M. on the 17th (distance from the earth 251,240 miles); and in perigee again at 4h. P.M. on the 29th (distance from the earth 228,430 miles).

The following ephemerides of comets 1892 VI. and 1893 I. may be useful:—

1892 VI.

		R.A.	Decl. South.	Br. (1·0 at discovery.)
September	1.	17h. 7m. 30s. ...	18° 21·4′ ...	0·159
,,	5.	9m. 35s. ...	17·9′ ...	0·146
,,	9.	11m. 51s. ...	15·3′ ...	0·134
,,	13.	14m. 17s. ...	12·6′ ...	0·124
	17.	16m. 53s. ...	10·4′ ...	0·115
,,	21.	19m. 37s. ...	8·6′ ...	0·106
,,	25.	22m. 29s. ...	6·8′ ...	0·098
,,	29.	25m. 30s. ...	5·2′ ...	0·081

1893 I.

		R.A.	Decl. South.	Br.
September	1.	0h. 22m. 42s. ...	8° 52·8′ ...	0.079
,,	13.	0h. 0m. 52s. ...	12° 37·3′ ...	0·069
,,	21.	23h. 46m. 38s. ...	14° 49·3′ ...	0·061
,,	29.	33m. 23s. ...	16° 42·2′ ...	0·053

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 12th of each month.

Solution of August Problem (A. G. Fellows):—

Key-move, 1. B to R3.

If 1. . . . K × R, 2. P to R6, &c.

If 1. . . . K to Q4, 2. B to Kt8, &c.

CORRECT SOLUTION received from R. B. Cooke.

Solution to "Alpha's" Sanscrit Contribution:—

1. R to R7ch, B × R.
2. Q to Kt8ch, B × Q.
3. P to Kt6, &c.

Correctly solved by R. B. Cooke.

Solution to Mr. Rosenbaum's Problem:—

1. Kt to Kt5, K to Ktsq.
2. R to K8ch, K to B2.
3. Kt to Q6ch, &c.

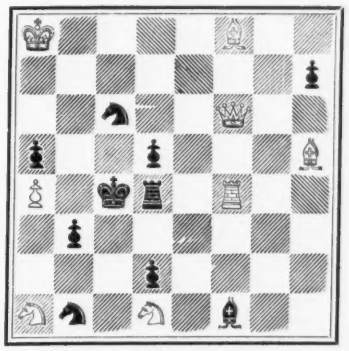
Correctly solved by R. B. Cooke.

W. A. Champion.—A good first attempt, but not quite correct. After 1. B to Kt8, K × B; 2. Kt to Q3, K to Q4 (best), there is no mate. Moreover, Black is not compelled to take the Bishop on his first move.

PROBLEM.

By C. D. LOCOCK.

BLACK.



WHITE.

White to play and mate in two moves.

The following game was played at the meeting of the Counties' Chess Association last month. The score is from the *Daily News*:—

"FIANCHETTO DEFENCE."

WHITE (Mr. J. H. Blake).	BLACK (Rev. J. Owen).
1. P to K4	1. P to QKt3
2. P to Q4	2. B to Kt2
3. B to Q3	3. QKt to B3 (*a*)
4. P to QB3	4. P to K4 (*b*)
5. P to Q5	5. QKt to K2
6. Kt to K2	6. Kt to Kt3 (*c*)
7. Castles	7. B to K2
8. Kt to Kt3	8. Kt to B3
9. Kt to B5	9. Castles
10. P to QB4 (*d*)	10. P to Q3
11. Kt to B3	11. B to Bsq (*e*)
12. B to K3	12. K to Rsq ?
13. K to Rsq (*f*)	13. R to KKtsq ?
14. P to KKt4	14. Kt to Ksq
15. Kt to K2	15. B to Kt4
16. Q to Q2 !	16. P to KB3 (*g*)
17. R to KKtsq	17. B × Kt
18. KtP × B	18. Kt to R5 (*h*)
19. R to Kt3	19. P to KR3
20. QR to KKtsq	20. Q to Q2 (*i*)
21. P to B4	21. P × P
22. Kt × P	22. P to Kt3
23. Kt to K6 !	23. Kt to Kt2 (*j*)
24. Kt × B	24. BP × Kt
25. B × P !	25. P × B
26. Q × P	26. Kt to R4 (*k*)
27. Q × Kt (R4)	27. Q to R2
28. R to R3	28. Resigns (*l*)

NOTES.

(*a*) Played by Mr. Owen's side in the last Telephone Match between Liverpool and the British Chess Club.

It tempts White to waste time by 4. P to Q5, Kt to K4 ; 5. B to K2, with a view to P to KB4.

(*b*) But this is quite contrary to the spirit of the close defence. The Bishop is left out of play, and a weak point is visible at KB4 (*vide* White's 9th and Black's 11th moves).

(*c*) He might perhaps have tried to free his game a little here by 6. . . P to KB4. On his next move the Knight should come out to B3.

(*d*) Chiefly to make room for his QKt, which cannot well play to Q2 on account of Kt to B5. But he might play 10. B to K3 and 11. Kt to Q2.

(*e*) Not much good unless he intends to take off the Knight at once. The usual manœuvre in these cramped positions is R to Ksq, followed by B to KBsq.

(*f*) With a view to aggressive measures. Black in the meantime still further cramps his King's position.

(*g*) A very ugly-looking move. 16. . . B × B, though not quite satisfactory, was probably safer.

(*h*) The losing move. 18. . . B × B, 19. Q × B, Kt to Bsq would be much better.

(*i*) Hoping to release his Knight by P to Kt3 and P × P ; but White by manœuvring his Knight to K6 shuts out the Queen. The advanced Black Knight consequently remains a prisoner.

(*j*) Overlooking White's winning reply. 23. . . Q to R2 has far more point.

(*k*) If 26. . . Kt (Kt2) × P, 27. P × Kt, Kt × P, B × Kt (or R to R3ch) wins.

(*l*) The other Knight has no escape after the threatened P × P.

CHESS INTELLIGENCE.

The Columbian International Chess Tournament is expected to commence on the 25th of this month. Messrs. Blackburne and Mason will be among the English representatives. Mr. Steinitz will not compete.

The return match between Messrs. Loman and Jacobs ended, as before, in a victory for Mr. Loman. Mr. Jacobs made a very good fight, especially in the earlier stages of the contest. Mr. Loman is now engaged in a match with Herr Teichmann.

The Counties' Chess Association held a very succesful meeting last month at Woodhall Spa, Lincolnshire. The victory of Mr. E. O. Jones came as a surprise to those who had made no allowance for improvement. Mr. Skipworth, a most inconsistent player, was evidently in his best form, while Prof. Wayte hardly played up to his reputation. The final score was as follows :—

1st Prize.—	E. O. Jones	5½
2nd Prize.—	Rev. A. B. Skipworth ...	4½
3rd Prize.—	J. H. Blake	4
	H. W. Trenchard ...	4
	Rev. W. Wayte	3½
	Rev. J. Owen	2½
	Dr. S. F. Smith... ...	2½
	C. J. Lambert	1½

Messrs. Gunston and Thorold were among the notable absentees.

"KNOWLEDGE" THREE-MOVE PROBLEM TOURNAMENT.

This will commence in the November number of KNOWLEDGE, and is open to the world.

The Proprietors of KNOWLEDGE offer the following prizes :—

1st Prize.—A full-sized Set of Staunton Chess-men.

2nd Prize.—Fifteen shillings.

3rd Prize.—KNOWLEDGE free for twelve months.

The Conditions are as follows :—

1. Each competitor may send not more than one three-move unconditional direct-mate problem (diagrammed).

2. Competing positions must be original and unpublished.

3. Each problem must be accompanied by a motto and full solution, with a sealed envelope containing the composer's name and address.

4. Competing positions must reach Mr. C. D. Locock, Burwash, Sussex, England, on or before October 10th, 1893.

5. The Chess Editor reserves the right of excluding manifestly impossible, unsound, or inferior positions.

6. Should more than twenty positions be received, the Chess Editor may, with the assistance of an expert, select the best twenty for competition. In that case the remainder will be returned to their respective composers without delay.

7. The adjudication will be partly by solvers and partly by a recognized expert.

All solvers who solve correctly every problem will be entitled to vote on their merits, the Chess Editor having also one vote. The six or seven problems thus selected will then be submitted to an expert, whose decision on their respective merits will be final.

SOLUTION TOURNEY.

1st Prize.—Half-a-guinea.

2nd Prize.—Bird's *Chess History and Reminiscences*.

This will commence in the November number, and will run concurrently with the Problem Tourney.

Two or three Problems will be published each month.

Solutions must reach KNOWLEDGE Office on or before the 12th of each month.

Marks will be awarded as follows :—For each correct key-move, three points; for each dual continuation (on the second move), one point. One point will be *deducted* for every incorrect claim. If a Problem has no solution, "No solution" must be claimed.

Duals will not count in Problems with more than one key.

CONTENTS OF No. 94.

	PAGE
Parallelism in Development. By K. Lydekker, B.A.Cantab.	141
Galls and their Occupants—II. By E. A. Butler	143
The Sun as a Bright-Line Star. By Miss A. M. Clerke	146
Science Notes	148
The Great Lunar Crater Tycho. By A. C. Ranyard	149
Letters :—J. R. Holt; W. T. Lynn; W. H. S Monck	153
Notices of Books	155
The Migration of Birds. By G. W. Bulman, M.A., B.Sc	155
The Face of the Sky for August. By Herbert Sadler, F.R.A.S.	158
Chess Column. By C. D. Locock, B.A.Oxon.	159

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